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COPPER STEAM PIPES.

THE lessons of experience form our best text-books, but the reading is sometimes difficult. The Ferranti multiple pipe, described at great length by the *Engineer* last week, is an admirably conscientious expression of one reading of the sad accident which occurred at Deptford in April, 1889. All honour to Mr. Ferranti for the emphasis of thoroughness which he has worked into this rectification of a former defect. If our contemporary had published his description of the new pipe design merely to inform engineers how the repair had been executed at Deptford, we should have read the article with only pleasure, and in cordial sympathy with the motives influencing Mr. Ferranti in scheming this form of pipe construction. The article is written with wider purpose—to help on the extension of this new fashion in pipes—and as the Board of Trade and Lloyds are always ready to work up their requirements to the standard of the very best that can be made, it seems to us very desirable to criticise the statements of our contemporary in regard to the failures of copper pipes as hitherto constructed and the superiority of the plan now advocated, lest a new fad be saddled on manufacturing engineers as an improvement.

For many years copper steam pipes were regarded as the most reliable of all the parts about engines and boilers. Steam pressures at sea had increased from 7 lbs. per square inch to 25 lbs. with very little additional thickness, and practically no failures. The pressures increased again to 70 lbs. with only a slight increase of thickness, not at all proportionate to the increase of pressure, and there was still no cause of alarm, for the copper steam pipes were equal to the normal duty imposed upon them. When in 1887 the working pressure had grown to be 150 lbs., copper steam pipes 9½ inches diameter designed to be made of sheets ·276 inch thick, were, in a case named in the article referred to, the ss. *Elbe*, considered to be amply strong. That is, they were designed to bear 2,578 lbs. per square inch of section of copper. At a certain part of one of these pipes at a longitudinal brazed seam at mid-length of a straight pipe, the sheets forming the pipe had not been held together as intended during the brazing, and the bevilled scarfs were only half lapped. Through the shifting back of the edges at the joint the effective thickness was there reduced to only a full $\frac{1}{8}$th of an inch, or, say, less than half what was designed. Over a length of more than 3 feet the mean thickness was only $\frac{3}{16}$ths of an inch. Not only was the effective thickness reduced at what was probably the commencement of the rupture to less than half of what was intended, but by the slipping of the lap the stress was applied in a one-sided way, not as a direct pull, so that the maximum intensity of stress at the section of rupture would be considerably greater than the calculated mean, 5,700 lbs. upon the square inch, or a little over 2½ tons per square inch, at a place where the copper would be exposed to the action of the fire in brazing, and where the planishing of the pipe would be done over a seam. The copper pipe gave way at this place after sustaining for some hours the intended pressure when the material at the section of rupture was under a mean tensile stress equal to that put upon steel piston rods. The factor of safety in construction is meant to allow for such defects in the quality of the material or in the workmanship as are not wholly avoidable in the best-ordered establishments. In this instance, the factor of safety had to cover accidental reduction of section, accidental injury in planishing, and accidental injury by overheating; and the experts who reported on the explosion asserted that all of these accumulatively contributed to bring about the rupture. Surely, the reading of this lesson is not that properly made copper pipes are now unreliable if the mean stress to which the material is subjected does not exceed, say, one ton per square inch—a limit which much exceeds that applied to copper steam pipes in the days when copper pipes established for themselves the good name which is now being taken away.

In another example given, the *Jumna*, for 160 lbs. steam in a 6-inch pipe at an elbow at the seam the section was only $\frac{1}{16}$th of an inch thick. Calculating as for a straight pipe the mean stress would be at this place 7,600 lbs., or considerably over three tons on the square inch. This had carried the working pressure for years without failure, and when it finally gave out, it is supposed that the ram action

of water in the pipe had contributed to determine the fracture at the instant the stop-valve was being opened. We need not go over the other similar cases named by our contemporary to cover copper pipes of the usual design with obloquy, and to justify its regret that the system did not die a natural death when the first pair of compound engines was fitted on board ship.

The Ferranti multiple pipe was begotten by the Deptford explosion. In this case we had a still more defective pipe—a copper elbow, 9 inches diameter, for 200 lbs. working pressure, was hammered out of sheets ¼-inch thick, and the drawing down of the plate at the joint gave an effective thickness only one-twelfth of an inch at the ruptured part, according to the very careful report of the Board of Trade inspectors. Calculating as for a straight pipe that would give the mean stress equal to 10,800 lbs. per square inch on the section of rupture, or more than 4½ tons per square inch, or making allowance for the arc form of the joint, say 3 tons per square inch.

The pressure never exceeded 152 lbs. up to the time of the explosion, so that the maximum steady stress would not exceed 2¼ tons per square inch. Here, again, there is nothing to be said against copper pipes, if made according to recognised engineering proportions for strength. This is how we read this steam-pipe fracture, even if it were due to fair steam pressure only. But when we look into the time and circumstances of the disaster, we are forced to the opinion, quietly but firmly expressed in the lucid report of the Board of Trade officials—the cause was water in the pipes. The arrangement of pipes, as shown on page 146 of the *Engineer* for August 16th, 1889, is as if contrived to reduce a water ram explosion when the stop valve is opened. If we understand the drawing, we think it would not be difficult to burst even the new multiple pipe elbow in the same place, if the receiver connections have not been altered. It seems to us that there ought to have been a small steam connection, say, an 1½ inch pipe from the top of the receiver on the steam side of the interceptor diaphragm to the under part of the steam-stop valve. The use of this connection would be to prevent the formation of a vacuum or low pressure on the surface of water in the main steam pipe near the receiver when the stop valve is opened. The steam could be trapped by an accumulation of water in the receiver, according to the original design. When the stop valve is opening the steam would escape into the vertical pipe, and the accumulated water would block the pipe from the receiver with full boiler pressure, propelling it into the space from which the air or steam had escaped. The small pipe suggested would render this action impossible, because the space between the valve and the water in the receiver would be open to the boiler steam.

So far, we have been endeavouring to show that the system according to which copper pipes have been *intended* to be made has not been at fault. The system has not been carried out, and the failures that have occurred have been due to the neglect of reasonable care in the execution of properly designed work.

We have now to consider the claim put forward for these multiple pipes. "An enormously reduced probability of explosion, due to the very great increase in strength of the multiple over the single pipe for the same area." We would like to have it pointed out to us wherein this great increase in strength lies. For the same pressure an 8-inch pipe ¼-inch thick is as strong as a 4-inch pipe ⅛th of an inch thick. The 8-inch pipe is twice the girth and twice the thickness, or four times the weight of the 4-inch pipe. The area of the 8-inch pipe is also four times that of the 4-inch pipe. We have therefore four times the weight giving four times the area and the same strength. It is therefore the same for strength and weight and area, whether the steam conduits are single pipes or multiples. The greater surface for radiation is admitted, we will therefore not refer to that.

Solid-drawn pipes can be made suitable for the single-pipe construction, and we think most engineers would prefer them. As to brazing the flanges, there is no need to braze flanges for straight solid-drawn pipes. Hammer over a three-quarter collar on each end and put a cast iron sleeve over them, pack at each side with asbestos and a pair of stuffing glands, and the joint is made.

There may be something in the minor considerations of the failure of one small pipe as against the failure of one large pipe, but we would urge that the pipes ought to be so made that there will no failure. If the Board of Trade and Lloyd's were to enforce a regulation that, calculating all over as for straight pipes, the mean stress at any section must not exceed one ton, or, better still, 2,000 lbs. per square inch, we would hear no more about failures of copper steam pipes, even if made of sheets and brazed. We would, however, as Mr. Ferranti does, favour solid drawn pipes, and for them we would think the 3,200 lbs. per square inch, which is what he allows, not excessive. The solid drawn pipe is not Mr. Ferranti's novelty, and our remarks are directed only to the multiple pipe system, which we think is unnecessary, and no stronger than single solid drawn pipes. The system is, however, very clever and ingenious; but how could it be otherwise coming from Mr. Ferranti?

OVERHEAD *v.* UNDERGROUND.

MR HIGGENS in his report to the Chelsea Vestry has collected a deal of interesting and instructive information, which is calculated to be of great service to those for whom he was writing as well as to others similarly situated. It is, however, much to be deplored that the all-important question of electrical line construction has never yet been adequately handled by competent and impartial electrical engineers. A perusal of Mr. Higgens's report, admirable as it is in many respects, will fully support this contention. It is very evident that a good deal of the information has been obtained either directly or indirectly from interested parties, such as telephone officials, the desire of whom has been to postpone their day of judgment by making the cost of underground lines appear to be prohibitively great as compared with that of overhead lines. It is, of course, quite understood that if the cost of underground work could be shown to be twenty-two times as great as the present system, the powers that be would probably hesitate to decree the abolition of what is fast becoming an intolerable nuisance in busy commercial centres.

In the report in question, the cost of fixing an overhead wire is given as £16 per mile, while that of an underground one is estimated at £350. To begin with, it is rather absurd to base the comparison upon single-wire lines, for no one

would dream of laying several miles of iron piping to carry a single wire, and supposing the pipe to contain even as few as twenty wires, the total cost, including wires, would, with infinitely better work than the telephone companies consider necessary, be less than £40 per mile per wire. On the other hand, it would not be possible to erect an overhead line at £16 per mile for the first wire, unless indeed the idea be to press householders' chimney stacks into the service, and stick insulator brackets into them, instead of employing poles in the orthodox manner. But even then the cost of maintenance would be great when we consider the damage which would be wrought upon the aforesaid chimney stacks. Obviously such a method of construction as this would be altogether out of the question for the London cobweb, and should not be taken as a basis for an argument. The cost of the poles alone would be considerably more than the sum stated, to say nothing of brackets, insulators, stays, the line itself, and the labour involved. In fact, what Mr. Higgens appears to have given is the cost of laying the underground work for one wire, as contrasted with the cost of running one wire with many others on an overhead line in the cheapest manner.

With regard to the life of an overhead wire which is said to be only six years, all we can say is that telegraph experience does not by any means bear this out, and it has not yet been permitted to the telephone companies to experimentally determine the matter. But stay! perhaps the estimate is based on the assumption of a collapse like that of 1886 occurring every six years.

We believe that the railway companies are paid one pound sterling per annum per mile per wire for maintenance, so that in six years they receive six pounds for each mile. However do they manage to cope with these six-yearly renewals and yet make it pay?

The statements on these points being so evidently wide of the mark, we are grieved to observe that the editor of an esteemed contemporary, in a leader on the subject, does not appear to have had sufficient confidence to criticise them. He falls in with the assumption that the life of an overhead wire is only six years, and proceeds to contrast that with the everlasting nature of a certain underground system in which the wires are placed in iron pipes. This system, in fact, appears to partake somewhat of the nature of the famous fuel which he recently brought before the public in his treatise on "First Principles in Electrical Engineering," which we had occasion in these pages to gently criticise.

For, in answer to his own enquiry as to the life of a telephone wire laid underground, he replies: "Is it six, or is it 60 years? There seems to be no reason why it should not be 600 years." Among other things it would be interesting to learn what arrangement he has made with the iron pipes to last this length of time. What with the fuel above referred to and this remarkable iron there would appear to be several things in earth (if not in heaven) not dreamt of in *our* philosophy.

But he finally concludes to fix the life at 60 years, and then remarks that the "cost of fixing" 100 or 1,000 wires underground will be little more than the cost of fixing one wire. We rather fancy that this depends to a certain extent upon what is included in the cost of fixing. Surely the making of joints should be included; and as about 8,000 more joints would be required to be made in the former case than in the latter, we think that our contemporary is hardly safe in committing itself to such a statement. Perhaps, after all, the article in question was only intended to amuse, and not to instruct. Referring to this charming theory about the cost of fixing 1,000 wires being little more than that of fixing one, it says:—"This is no new conclusion on our part." . . . "The telephone company that has monopolised London had a splendid opportunity of testing the correctness of these views, but they have clung to overhead work," &c. All we venture to remark is that as the prime object of the formation of the telephone companies is the earning of dividends, we consider that they were wise in clinging even to their overhead work rather than testing the correctness, &c. A special company should have been floated for the latter purpose.

After all there is little or no scientific difficulty in the way of working underground circuits either for telegraphic or telephonic purposes in such an area as that of London. Probably the greatest difficulty would be experienced in finding accommodation for the pipes in the already crowded soil under the pavements; but the relative cost of the two systems would certainly be far less disproportionate than one would gather from a perusal of the report of the Chelsea surveyor.

THE CENTRAL LONDON RAILWAY.

Unless some extraordinary obstacle, of which no one dreams at present, is laid in the way, Central London will have its own railway. The Bill for authorising the construction of an underground electric railway from the heart of the City to Shepherd's Bush has been read the second time in the House of Commons; it got past the Select Committee, and it is now ready for the House of Lords. The measure came before Parliament last session, but it was lost in the House of Lords, mainly on the ground that it was considered premature, and that it might very well stand over for a year pending the results of the working of the City and South London Electric Railway.

Last year the proposed line was to stop at Queen's Road, and the generating plant was to be erected there. If that had been done, the plant would have been in the midst of very valuable property, and the Committee felt some anxiety as to the effect of this undertaking in such a neighbourhood. According to the new Bill the generating station will be at Shepherd's Bush, and the proposed line will be 6 miles long, instead of 4½ miles, as stated last year. The tunnel will be laid, on an average, 50 feet below the surface of the streets, but in some places it is intended to go 70 to 80 feet deep, below the surface of London clay. The maximum gradient would be 1 in 100, and from Notting Hill to Tottenham Court Road the line was absolutely level. It was proposed to run the electric trains at a maximum speed of 25 miles per hour, which would give, inclusive of stoppages, an average of 15 miles per hour, or about 25 per cent better than the Metropolitan Railway speed. The journey from the Marble Arch to the Bank would thus take 15 minutes. It was proposed to build 13 stations on this line. Two iron tunnels, each 11 feet 6 inches internal diameter will serve

the up and down traffic. Mr. T. H. Greathead's system of construction, which has proved so successful south of the Thames, will be adopted on this line. Mr. Greathead stated, before the Select Committee, that on the City and South London Railway after a little practice they were able to tunnel 16 feet a day at one facing, and for several weeks together the rate was 15½ feet per day; while at one time they did over 100 feet of tunnelling a day. The progress in six months was equal to 2¼ miles of completed tunnel. At this rate, with two facings worked simultaneously, the 6 miles of tunnelling in the Central London Railway could be accomplished within 16 months.

Each train would carry 336 passengers, and it was intended to have two classes. On the South London, it will be remembered, the train capacity is 100 passengers, and there is but one class. We travel very frequently on the latter line, but have heard no complaints about the democratic innovation of "one class," and it seems taking a retrograde step in introducing the class division again, especially as the Central Railway cars are to be constructed with end entrances, which have been found very convenient.

The generating station at Shepherd's Bush would be above ground. A main conductor would be laid all along the line which feeds the naked working conductors from which the locomotive drew the current as it proceeded. The direct current, low tension system, such as the Board of Trade approved on the South London line, would be adopted. The hydraulic power for working the lifts at all the stations would be produced at Shepherd's Bush and conveyed through pipes along the tunnels. After the water had done its work it would be returned and used over again.

Passing to other statistics, it was stated that the estimated cost of works, land and buildings, would be £2,173,515, and to this must be added the cost of equipment, cars, electrical plant, lifts, &c. The cost of the trains would depend on the frequency of the service. If a three-minute service was required this cost would amount to £600,000. In order to keep up a three-minute service,18 trains would be required on the line, each train to weigh 120 tons, and this worked out to 2,160 H.P. at the stated speed. The trains were intended to consist of six carriages, having 56 seats each, so that over a double line of railway with those cars and with the engines to be provided, they would be able in an emergency to carry 350,000 people a day. The loaded trains on the City and South London Railway weighed 39 tons; the average number of passengers was 15,000 per day; during the first two months 900,000 passengers had been carried and 60,000 train miles had been run most satisfactorily.

The experience gained on the South London line would enable the constructors to avoid all defects on this new railway. The breakdowns that had occurred had arisen from small mechanical defects, which were perfectly remediable. It was to be expected that there would be stoppages of that kind at the outset, but most of them have been completely overcome. Altogether there had been about 20 stoppages during the two months. The longest was for 1½ hours on one occasion, but as a rule the stoppages had been only for a few minutes. The defects had been remedied, and there was no serious fault in the system, which, as a matter of fact, was perfectly workable.

With respect to the projected Central Railway, Dr. John Hopkinson explained that the circumstances of the case were in some points more advantageous than those of the South London line. It would be longer, the trains would be more frequent, the loads heavier, the gradients less severe, and the curves not so sharp. All the points, in fact, were in favour of easy working. The maximum power one train would require at any moment would be about 300 H.P., and the total power at the generating station would be 3,000 H.P.; the maximum pressure allowed is 500 volts. With regard to cost, he put the expense for boilers, steam engines, dynamos, conductors in the tunnels fixed in places, and locomotives, at £335,000, allowing 30 locomotives to run the 20 trains. His estimate of the cost of traction per train mile came out at 8·9d., but it might be taken that 9d. per train mile would be the extreme limit of the cost of running these trains.

Hampering the Central London Railway.

IN the early days of Railway enterprise Parliament took care of the poor when it imposed on every company an obligation to run one train a day along its whole line at a fare not exceeding one penny a mile. The workmen's trains which run at early hours are charged, as a rule, much less, and do not lose by the traffic. The promotors of the Central London Railway were willing to take all passengers at the rate of a penny for three miles, which certainly seems a most moderate charge; but the Select Committee of the House of Commons was determined to seize the opportunity of adding to the advantages of the workman, and insisted that there should be three trains a day, each way, run at the rate of one penny for the whole six miles. Thus, instead of the penny a mile under the old Act, workmen will be carried six times the distance for the same fare. The promoters of the Central Railway, at first demurred to this large demand for cheapness, but, rather than withdraw their plans, they finally acceded to the imposition. Considering the enormous cost of such an undertaking, and the immense convenience to the public at large of this most desirable means of transit through some of the principal parts of our great city it seems a pity that the Company should be thus hampered in its initial stage. Three and a half million pounds is a big sum to embark in an undertaking which represents only six miles of railway, and one which should not be compared with ordinary surface railways and tramways where the initial outlay is small in comparison with underground roads. But it seems that Mr. T. H. Bolton is not yet satisfied, for he intends to propose, when the Central London Railway Bill returns to the House of Commons, that six workmen's trains shall be run both morning and evening, instead of the three arranged by the Select Committee, and that they shall continue up to eight o'clock instead of seven. He will also strive to procure for warehousemen, porters and messengers the benefit of the concession, as of right, as well as artisans, mechanics, and daily labourers. Perhaps, in the near future, when similar undertakings may be projected, Parliament will ask for free passes for working men as a condition to get a Bill passed, since there is a popular notion in the minds of some of the editors of dailies that electricity is dirt cheap. The *Daily Telegraph*, for instance, says: "in all probability the company will realise a handsome profit even out of these very cheap trains. When a line is once made, and plenty of rolling stock purchased, the running of a few extra trains, even on the lines where steam is used, comes to practically the expense of the few hundredweight of coal used on the journeys. The actual amount of electrical force expended on the cheap Central trains will probably amount to less." When daily papers are recognised as "necessities" then it may occur to the *D. T.* proprietors to give away to workmen copies of their journal.

ELECTRICAL NEWS FROM AUSTRALIA.

[FROM A CORRESPONDENT.]

The latest thing of importance which has occurred here is the completion of the lighting of Newcastle, which was publicly opened early in January.

It is a very complete sample of the Westinghouse system, and has been well carried out down to every detail. There are two 750-light, 1,000 volt alternating current Westinghouse dynamos, with separate exciters; both dynamos and exciters being driven direct from the engines. The engines, of which there are two, are of the Westinghouse make, indicating 75 horse-power, supplied with steam at 120 lbs. pressure, from two Babcock and Wilcox boilers. In addition to these, which are for the incandescent circuits, there is a Brush arc light dynamo driven by a small Westinghouse engine of about 25 H.P. indicated.

The usual Westinghouse system is used for the street circuits; the incandescent lamps, which are run at 50 volts, being run in multiple, are in groups of 20 in series.

There are at present 400 incandescent lamps on the street circuits; the surplus power from the dynamos will, of course, be used for house lighting as soon as the Town Council can get their Act passed, allowing them to go in for public supply.

In Hunter Street, the principal thoroughfare, there are 23 Brockie-Pell 2000-candle-power arc lamps, suspended by cross wires, in the centre of the street.

The cables, which are Callender's throughout, are all overhead, and there has been a good deal of friction with the authorities of the Telegraph Department as to the haphazard way the cables crossed the telegraph wires without any guard wires.

The switchboard is very handsome and made of colonial woods. On the switchboard there was a novelty to us in the shape of cut-outs with a platinum wire indicator. The engine shed, is 75 feet by 30 feet, and allows ample room.

The work was planned and carried out for the contractors by Mr. E. J. Erskine, under the supervision of Mr. G. Hitchcock, of the Westinghouse Company.

The contract for the lighting of Redfern has been awarded to the Williamson Electrical and Engineering Company, for £10,336. Their tender was originally for £11,536, but the £1,200 was knocked off for poles, as the Corporation have decided to put in iron poles themselves. There are to be 400 street lamps of 25 candle-power each. The Council have already purchased a site for the station.

The tender for the lighting of Burwood has gone to Messrs. Wood Bros., who had the contract for lighting Moss Vale. I hear that there was only one other tender put in besides Messrs. Wood's, and this was only on half a sheet of paper, whereas Messrs. Wood's was very complete.

I am sorry to say that Australia has added its quota to the list of deaths from electricity. The accident occurred at the new works of the Australasian Electric Company, at South Richmond, Melbourne. There are two machines in the building, one of which is kept running throughout the day, and as it is also kept running at night, with the second dynamo, it becomes necessary to stop it in order to thoroughly oil and examine it before allowing it to run all night. While this is being done the circuits are switched on to the second dynamo, so as to prevent an interruption of supply. The engineer in charge was in the act of changing the circuits, when Pattison, the deceased, who was standing in front of the switchboard, advised him to be very careful on account of the high potential. The engineer replied, "All right." Having changed the circuits, he glanced at the adjourning switchboard, and was horrified to find Pattison fastened to it by both hands, and unable to let go. He immediately switched off, and Pattison fell to the ground without uttering a sound. He was given a cup of water, which he drank, but he died within five minutes. At the inquest it was ascertained that he had himself designed and constructed the switchboard.

I see that the Melbourne Town Council are advertising for an expert to advise them in the matter of lighting the town by electricity.

Hobart is also advertising for tenders for lighting. They intend using water power. Their consulting electrician is, I believe, Dr. Stern, late of the Ganz Company.

This, I think, furnishes all the items that I have heard of since I last wrote to you.

PHYSIOLOGICAL EFFECTS OF ALTERNATING CURRENTS OF HIGH FREQUENCY.

By ELIHU THOMSON.

In connection with an experimental investigation of the properties of alternating currents of high frequency and the phenomena which they present, it had occurred to me that it would be desirable to obtain data concerning the relative physiological effects of these currents as compared with the effects of currents of ordinary frequency. I had constructed a machine on the type of my new alternating dynamo, accounts of which were published some time last year. In this machine an iron mass only is revolved, the central portion of which carries projections which pass near to the coils in which the currents are induced, which may be termed the armature coils, carried on the inner face of a laminated structure, in turn supported by the outer frame work of the machine. The machine with 100 armature coils and a speed of 5,000 revolutions per minute, gives a little over 8,000 alternations per second. The publication of brief notices of some of the results obtained in the operation of this machine led Dr. Edward Tatum, of Yonkers, N.Y., to correspond with me with the view of finding out whether I had intended to conduct any physiological experiments with the currents, and indicating his desire to experiment in this direction if the machinery for obtaining the currents could be placed at his disposal for a short time. Accordingly, the machine was sent to Dr. Tatum some time last fall, and was used by him in making a series of experiments, the results of which cannot fail to be of the highest interest to electricians and physiologists. Very unfortunately, Dr. Tatum has been an invalid since January last, and has therefore been prevented from writing up the results which he obtained, some of which were transmitted to me in a letter dated December 29th, 1890, before he was taken sick. I will premise by saying that Dr. Tatum had intended to continue his experiments further before publishing any results of the trials. I quote from Dr. Tatum's letter as follows:—

"The most definite and perhaps the most striking as well as physiologically instructive result has been in regard to the fatal efficiency of such rapidly alternating currents. When the circuit is formed through the head and body (of dogs), death occurs in the same manner as with other sources of current (which are made strong enough to kill by a closure lasting not more than two or three seconds), that is, by primary arrest and paralysis of the heart; but taking the fatal efficiencies of different sorts of currents as inversely proportional to the current strengths required to kill under otherwise similar conditions, a rate of 4,500 per second is not only far less efficient than rates of a few hundred, but it is distinctly less efficient than a continuous battery current. Indeed, in four of the five dogs that I have killed at the high rate, a stronger nominal current was required than I have ever before used (with a single irrelevant exception) to kill a dog. A nominal current of 1·35 amperes was entirely recovered from; the animal on the following morning showing no signs of physical or mental disturbance. This is four times the strongest fatal current at 300 alternations that I have used on normal dogs; six times the strongest current survived, and 13 times the weakest fatal current. It is 13 times the strongest fatal current used at 120 alternations; 20 times the strongest current survived, and 18 times the weakest fatal current. It is remarkable that rates of 300 and 120 alternations per second are fatally efficient at very nearly the inverse ratio of the numbers; but still more remarkable that the very highest rates should also present a strikingly near approach to a similar ratio. It must be noted, however, that no such ratio can hold throughout the whole range, for 36 alternations per

second (from the same machine as furnished 120 and the 300 rates) are again distinctly less efficient than 120, something like two-thirds as efficient."

Dr. Tatum goes on to point out that a potential of 450 volts was survived at the high rate of alternations and the fatal current only reached at 495 volts, while 45 volts at 120 alternations similarly applied to the dog suffices to pass a fatal current. Dr. Tatum also determined the ratio of pressure or potential to current in the dog just after the cessation of respiration, using in rotation, twice repeated, first a continuous pressure or potential, secondly, an alternating one at a rate of 120, and, thirdly, an alternating potential at a rate of 4,500 per second at about 100 volts, and states :—

"This ratio was so uniform (the extremes observed differing by less than 3 per cent.), as to dispose of any suspicion that the high period currents distributed themselves essentially different from others in the animal's body."

I will continue to quote from the Doctor's letter, as the results he obtained could not be so well expressed by myself as he has done in relating them.

". . . . In regard to the physiological as distinguished from the fatal characteristics of the high period machine, I am only able to state the results in terms of pressure instead of terms of current as I should prefer. The limits of voluntary toleration for alternating pressures (applied with sponge electrodes) seems to depend very little on the frequency of alternation. For all the frequencies I have mentioned, the limit has been found between 10 and 15 volts for applications about the face and head, and between 40 and 50 volts between the hands, without any decided preference in either case for one rate more than another."

"The cause of the pain which limits voluntary toleration seems to be in all cases chiefly in the muscular contraction produced. At 4,500 this muscular contraction is usually free from the thrill experience, even at 300 ; resembling, on the temples, nothing I can think of so much as firm pressure with the knuckles.

"The cutaneous nerves are distinctly less painfully affected at the high rate.

"The visual mechanism cannot be excited at the high rate even by a pressure of 15 volts, so as to cause a sensation of flashes of light, although two or three volts similarly applied at 120 alternations cause such flashes very energetically.

"The sensation of dizziness caused by a few (four or five) volts applied behind the ears at a low rate of alternation of current cannot be produced at the high rate.

"Sensations of taste are also absent.

"Directly applied to the exposed motor nerves and muscles of dogs and frogs, pressures at high frequencies seem less efficient as stimuli than at lower frequencies, in something like the same ratio as their killing power.

"The establishment of anything like an exact ratio I have not accomplished, owing partly to the very low pressures which acted as very energetic stimuli when applied directly to fresh nerves. Thus a nominal potential difference of $\frac{1}{30}$th of a volt in a length of 8 mm. of a frog's sciatic nerve still causes vigorous reaction. As the portions lose their vitality, however, stronger and stronger stimuli become necessary to elicit a response, and it is during this period of failing vitality that something like the above proportion is indicated between the respective pressures required to just produce a visible reaction."

Dr. Tatum's letter also contains references to the work which he had planned to carry out in the near future concerning the relations of alternating currents of high period to vital structures, which work he had been, I regret to say, prevented from pursuing by sickness, from which he has not yet recovered.

He also makes the inquiry as to the practicability of constructing a machine to deliver currents at a rate of 40,000 to 50,000 per second, such machine to be used in continuing the investigations, some of the results of which are given in his letter.

I take great pleasure in being of service to Dr. Tatum in presenting some of the results of his very able investigations, feeling sure that they cannot fail to be of the highest interest to physicians, electricians, and many others. In presenting these results I take occasion to express my sincere regret that ill-health has prevented the continuance of the work in the direction laid out by the Doctor himself, and to express, also, the hope that he may be able to take up the further investigations at some other future time.

[This very interesting communication seems to entirely confirm the results already made known in this country by Dr. Harries and Mr. Laurence, whose recent paper and the discussion thereon we shall publish next week.—EDS. ELEC. REV.]

ELECTRICAL CONDUCTORS FOR MINES.

By CHARLES BRIGHT, Assoc., M. Inst. C.E.

DURING the discussion on Messrs. Atkinson's recent paper on electric mining machinery at the Institution of Civil Engineers, the dangers connected with electrical mains in a mine were alluded to as an argument against electricity being applied to mining machinery ; moreover, darkness and dampness were specified as a condition under which such conductors would be at a disadvantage.

The paper in question did not advocate any particular class of main for carrying the current ; but, supposing for the moment, that a conductor covered either with vulcanised India-rubber or gutta-percha were adopted, darkness would be a distinctly *favourable* condition rather than otherwise, both for gutta-percha and India-rubber ; and dampness, in like manner, would be a peculiarly favourable state of affairs, particularly for gutta-percha. It is under the combined circumstances of darkness and dampness that the electrical and mechanical value of gutta-percha as an insulator is not only well maintained but is considerably enhanced by submergence under the depths of the sea.

It must be remembered, moreover, that gutta-percha and India-rubber have already shown themselves to be well adapted to mines for electric lighting purposes.

Gutta-percha (provided there is enough of it to cope with the risk of decentralisation of the conductor due to the effects of large currents unduly heating it) is found particularly well suited as an insulator in mines, especially where it has the advantage of being less subjected to light and cold, which tend to cause cracking. In point of fact a core which is in any way armoured, is not, of course, much troubled by the presence of light.

A vulcanised India-rubber cable is also favourably situated in a mine, provided it is well made, and, above all, provided the joints are of a workmanlike character. Under such conditions it has one advantage over gutta-percha (beyond the fact of its being less affected by temperature) which is that it stands better such rough treatment, as may be expected.

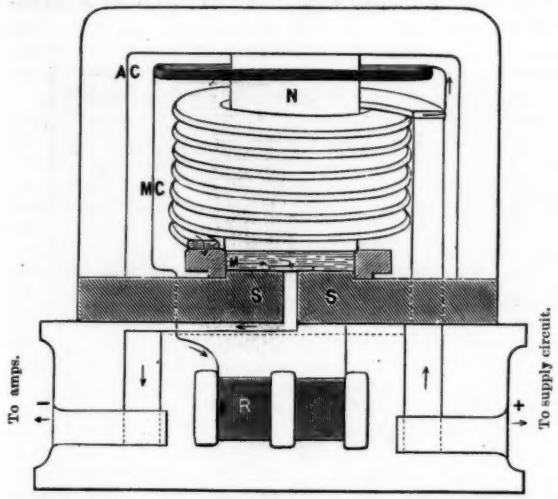
In earlier days, gutta-percha would have been preferable for mines, but since the advances made in the manufacture of vulcanised India-rubber, both as regards the joints and otherwise, the latter is probably better suited for the purpose.

FERRANTI'S ELECTRICITY METER.

THE Ferranti meters both for alternating and direct currents are the result of a patient endeavour to produce in their most perfect forms instruments possessing the three essentials, simplicity, accuracy, and reliability. The principle of the Ferranti meter is the measurement of the rotation of a bath of mercury through which the current passes from the periphery to the centre after energising a magnetic field, the lines of force of which are at right angles to the radial direction of the current in the mercury. The speed of rotation increases in proportion to the current, and the movement is transmitted to the register by a fan which is mounted on a light spindle and immersed in the bath. The registering of the meters is as simple as their mechanism. The faces are marked with six dials—units, tens, hundreds, &c, and the amount registered on these when divided by the constant stated in the instructions, will give the number of Board of Trade units consumed. An important feature of the Ferranti meter is the extremely small amount of energy required to work it, and the consequent absence of any observable drop in volts, due to resistance or work being put in series with the lamps. There is only one moving part, and this is

perfectly enclosed in a metal case and entirely inaccessible to any of *the defects to which a more open form must sooner or later be subject*. They are unaffected by external influences;

FERRANTI METER.

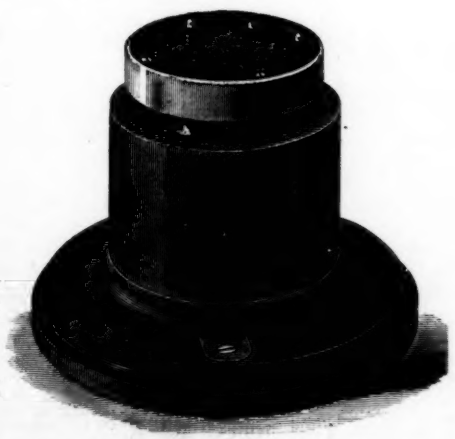


A C, Auxiliary coil; M C, Main coil; M, Mercury chamber; R, Resistance in series with auxiliary coil.

indeed the correctness of their record is not impaired (as would be the case in some other direct current forms) by a magnet being placed near them, as might be done by a dis-

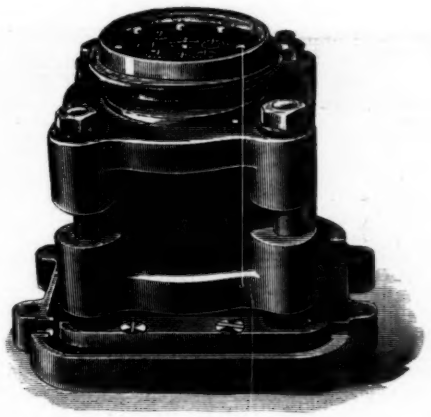
FERRANTI METER.

honest consumer. They are in brief motor meters of the simplest attainable form, and as such do not require to be touched for winding up or recalibration. They are made



10 AMPÈRE FERRANTI METER.—CASE REMOVED.

entirely of uninflammable material, can be quickly installed and connected, and are suitably designed to prevent their being tampered with afterwards. As regards accuracy, a great disadvantage of other forms of meter is their inability to start registering at a small fraction of their full load, that is to say, when the friction of the working parts is greatest relatively to the force to overcome it. A consideration of the design of the Ferranti meter will show that in it this friction is at a minimum, but even so far its effect is largely reduced by a simple



40 AMPÈRE FERRANTI METER.—CASE REMOVED.

and effective device consisting of a fine wire coil through which a minute shunt current passes round the iron core and produces a strong magnetic field relatively to the small current passing through the bath at low readings. In some sizes of direct current meters the residual magnetism of the field is arranged to take effect and the fine wire coil is dispensed with. By this means Ferranti meters will start registering at about 1 per cent. of their limits of load, and will register with less than 3 per cent. error over 97 per cent. of their working range, *i.e.*, for instance, a 100 ampère meter will start registering at 1 ampère, and will register correctly from less than 3 to 100 ampères.

The following are examples of tests taken with three forms of meter: 40 ampère alternate current mercury meter—shunted. Started with ·3 ampère. Mean constant, 7·56 over the last 95 per cent. of their range. Variation—above, 1·85 per cent.; below, 2·12 per cent.

Ampères.	Revolutions per ampère per minute.
2	7·6
5	7·55
10	7·4
15	7·44
20	7·4
25	7·7
30	7·59
35	7·67
40	7·63

100 ampère direct current meter. Starts with ·5 ampère. Mean constant, 2·838 over the last 90 per cent. of their range. Variation—above 1·3 per cent.; below ·99 per cent.

Ampères.	Revolutions per ampère per minute.
2	2·875
5	2·34
10	2·325
25	2·33
50	2·34
75	2·83
100	2·81

10 ampère continuous current mercury meter—unshunted. Started with ·2 ampère. Mean constant 23·56 over the last 95 per cent. of their range. Variation—above 3·93 per cent.; below 2·37 per cent.

Ampères.	Revolutions per ampère per minute.
·3	23
1	24·5
2	24
5	23
7·5	24
11	23·2
13	23·25

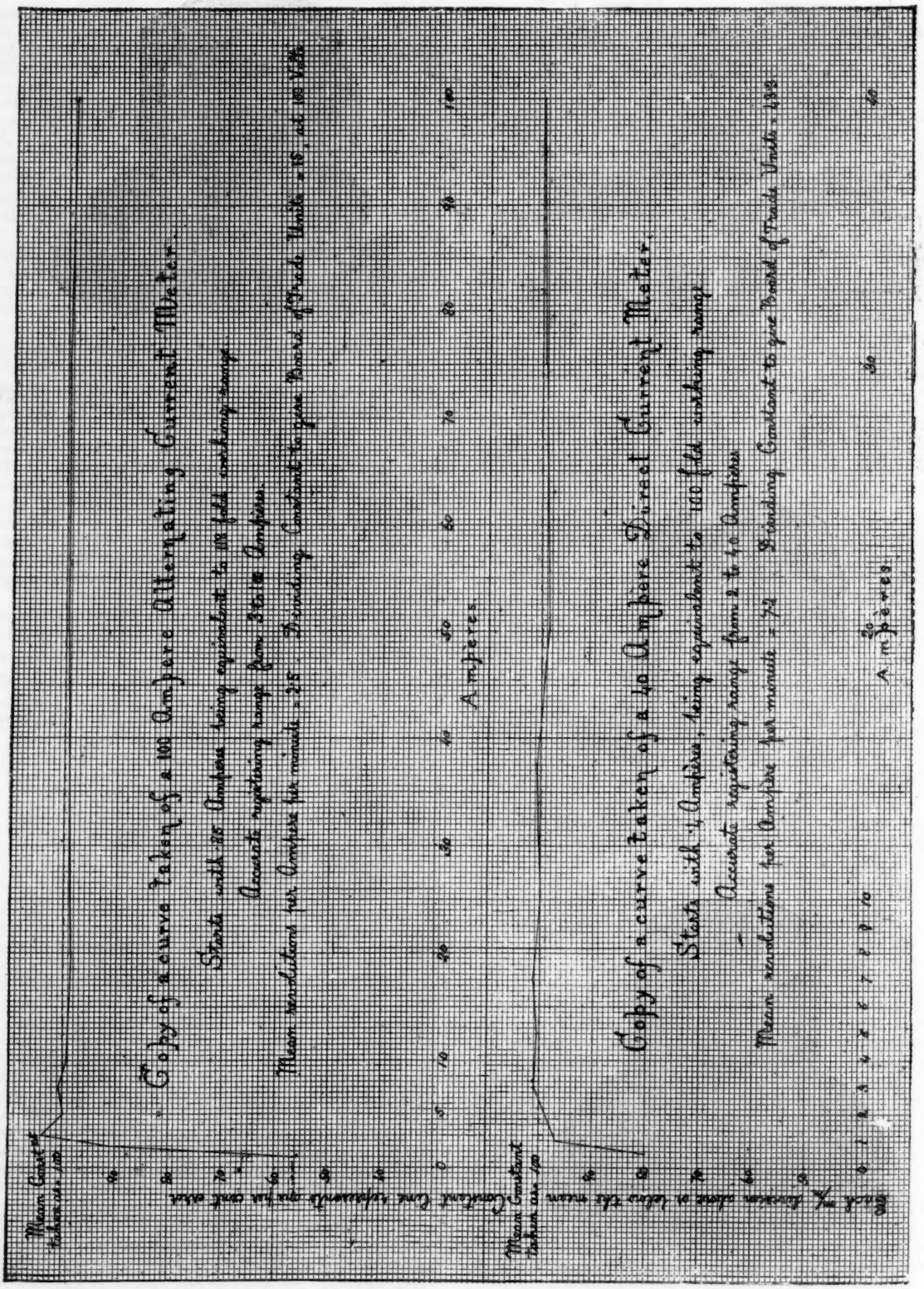
INDIA-RUBBER CORE IN SUBMARINE CABLES.

A RECENT number of the New York *India-Rubber World* contains a short article on the question of the employment of India-rubber as a dielectric for submarine cables in place of gutta-percha. The article to which we refer advances as arguments in favour of India-rubber :—

1. The constantly increasing cost of gutta-percha, which at the present priee would make India-rubber core about 30 per cent. cheaper than gutta-percha core ;

2. The immunity of India-rubber from attack by the *teredo ;*

3. The greater facility with which joints can be made in India-rubber as compared with the same operation in gutta-percha ; and


Copy of a curve taken of a 100 Ampere Alternating Current Meter.
Starts with 25 Amperes being equivalent to 10 fold working range.
Accurate registering range from 3 to 80 Amperes.
Mean conditions for Amperes per minute = 3.5 Standing Constant to give Board of Trade Units = 15, at 80 Volts
Amperes
Copy of a curve taken of a 40 Ampere Direct Current Meter.
Starts with 1 Ampere, being equivalent to 160 fold working range
Accurate registering range from 2 to 40 Amperes
Mean conditions for Amperes per minute = 1.2 Standing Constant to give Board of Trade Units = 133
Amperes

FERRANTI ELECTRIC CURRENT METER.

4. India-rubber in submarine cables is in no wise inferior to gutta-percha as regards durability.

To the best of our belief the foregoing statements, though

possessing some elements of truth, are, to a considerable degree, misleading. We would suggest certain modifications which, *pace* manufacturers, we venture to particularise as follows :—

1. Although the price of gutta-percha of a good quality is higher than that of India-rubber, yet it must be borne in mind that the manufacture of India-rubber core for submarine cables is a more difficult, and consequently more expensive, process than that of gutta-percha ;

2. With regard to the *teredo*, our contemporary may be correct in stating that this insect does not "pass its plate for more" when offered India-rubber core, so far as the Persian Gulf cables are concerned ; but we have always understood that in other parts of the world India-rubber has been found to suffer equally with gutta-percha from the attack of this borer.

3. With respect to jointing, the writer of the article must have had in mind the operation as frequently performed in electric light installations. As a matter of fact, although trustworthy joints can be, and are, made in India-rubber core, in submarine cables they are more difficult to make than in gutta-percha core, and take more time ; and

4. As to the durability of India-rubber core we can scarcely form an opinion, but we would point out that in the case of the Persian Gulf cable, which our contemporary quotes in support of his contention, and in the India-rubber core cables laid on the Brazilian Coast for the Western and Brazilian Telegraph Company, whenever a repair has been necessary, gutta-percha core has invariably been substituted for the India-rubber. But this substitution may have become imperative for reasons not entirely attributable to imperfections in the dielectric.

An argument frequently used against the employment of India-rubber core in deep-sea cables is the great elasticity of the India-rubber dielectric as compared with that of the copper conductor conducing, when any considerable strain in laying is experienced, to buckling. It would seem, however, that this danger could be obviated by employing closely-sheathed cables, avoiding those types frequently used in deep water which give a large percentage of elongation.

The most serious objection, however, to the employment of India-rubber core in submarine cables is the difficulty experienced in localising faults in those portions of a section which may be subject to occasional movement or disturbance. As can be readily imagined, this difficulty becomes pronounced in repairing work when the cable has to be grappled for and picked up, the least change in the position of the cable completely sealing a fault previously observed as an extremely serious one, or, on the other hand, giving unexpected evidence of a notable defect in the insulation, hitherto unsuspected.

Whatever may be the arguments used for or against the employment of India-rubber core in submarine cables, the *India-Rubber World* has broached a subject which ere long must become a matter of serious consideration. Not only is the supply of gutta-percha becoming scarce, but the quality of the gums actually within reach of the consumer is such that the better known firms of submarine telegraph engineers have been compelled to insist, in all specifications with which they have to deal, upon not only a minimum insulation, but also upon a maximum. When the supply of gutta-percha altogether ceases, a consummation likely to occur before many years elapse, what are we to fall back upon ? Little, indeed, is to be expected from the Karité, or "butter tree," recently announced as the successor of gutta-percha ; the fact of its differing in chemical constituents, though but slightly, from gutta-percha, is sufficient evidence against it when we consider that the apparent chemical differences between a gutta-percha gum of a good variety, and one so inferior as to be utterly useless as a dielectric, are inconsiderable. No other practical substitute has been discovered, and we must consequently look upon India-rubber as the dielectric of the future for submarine cables.

Although we have pointed out the existence of certain difficulties in the manufacture and in the jointing of India-rubber core, the difficulties are only such as necessitate some extra care in the treatment of the material, and they can be, and indeed are, readily overcome by competent manufacturers. As a proof that India-rubber is considered a suitable insulator for submarine cables, the Cuba Submarine Telegraph Company have recently had manufactured and laid for them about 160 N.M. of India-rubber core cable between Cienfuegos and Batabanó, on the south coast of Cuba. This dielectric was adopted after an experience of nine years with a similar type laid between Cienfuegos and Santiago de Cuba, a considerable portion of this section lying in over 1,500 fathoms.

Our contemporary states that "it is generally supposed that gutta-percha is the only practical insulator that can be used in submarine cables." It has apparently overlooked the fact that more than 20 years ago there were laid in the China and Japan seas some 2,300 N.M. of India-rubber core cable, and in 1869 about 800 N.M. of the same dielectric in the German Ocean.

Without advocating or condemning the use of India-rubber in submarine cables, we must recognise the fact that if cables manufactured 20 years ago are now in capital working order, there is good evidence in support of the contention that India-rubber core possesses the quality of durability ; the experience gained by manufacturers during this period cannot but tend towards improvement in the treatment of this material.

In summing up the arguments for and against the employment of India-rubber in submarine cables, the evidence upon which an opinion might be based appears somewhat conflicting. It would seeem, however, that the only difficulty with regard to its use which cannot be overcome is the uncertain behaviour of a faulty core when tested. With this exception, and it must be admitted that the point is a very serious one, there is no ground, so far as we aware, for regarding the general employment of India-rubber core in submarine cables with any particular distrust.

KENNEDY'S NEW ELECTRICAL DISTRIBUTION METHOD.

By RANKIN KENNEDY.

The System.

The system as a whole is shown diagrammatically in fig. 1. The dynamo, D, is shown of the simplest possible form for producing the two currents alternating in quadrature, there being only two coils in the armature wound on at right angles. C^1 and C^2, are rectifying commutators of the ordinary well-known split tube form ; the collecting brushes, F^1, F^2, F^3, F^4, make contact at the positions, as shown in the diagram.

As shown in the diagram the machine is self exciting, the current in coil K, is a unidirection pulsating current, and so is the current in coil L, but the one being at a maximum, while the other is at a minimum, as shown in diagram fig. 4, their magnetising effect is constant.

Coil G is the conductor between the two circuits, as represented in fig. 5, March 7th, connecting the two batteries ; all current passing across through translating devices from the one circuit to the other, passes through coil G. Now if coils K and L were series coils instead of shunt coils as shown, and the machine separately excited it would be automatically self regulating, or a series and shunt winding could be easily arranged to excite from the two circuits without separate excitement. The generators on this method are therefore superior to the generators on the simple alternating systems. In fact they have all the advantages of the compound wound self-regulating direct current dynamos.

Now as to working dynamos in parallel on this system, it may be explained that so far as the dynamos may be considered they are for this purpose alternators, the current in the armatures would be in quadrature, and also in quadrature together in the same armature coils, the two circuits being in series. This at first sight complicates the problem of parallel working of the generators ; really it does not alter the problem much from that for ordinary alternators. For synchronous co-phased parallel running the magnetic effect of the current in armature coils is the power, in fact the only power in operation to keep machines running in step. In this system the two currents in series in the armature coils, although in quadrature they produce a periodically reversed magnetic effect, which has the same tendency to keep the

machines in step as the reversed magnetic effect has in ordinary alternators.

The difficulty with ordinary alternators, is to start them in parallel; here the new method has the advantage. The dynamos start off from a state of rest simply by switching on the current first to the field coils, and then on to the armatures. The commutators enable this to be done easily, the currents being unidirection currents. The dynamos act exactly as shunt wound continuous current motors; and like such motors the dynamo so switched on to the circuits would run up in speed until its counter E.M.F. is nearly equal to that of the circuits. There would not necessarily be synchronism of phase at that speed, but if this speed is approximately the synchronising speed (and it can be brought to the synchronising speed by varying the field excitement) there is a strong tendency on applying power to drive the dynamo as a generator, to fall into step with the other generators. Fig. 2 shows two dynamos coupled in in parallel on this new method.

Referring to the circuits shown in fig. 1, there are three circuits, two of them for working translating devices with double parallel windings, shown at O and R, and a third for working single wound constant current devices or for storage battery charging. A storage battery is shown at B, an ordinary high pressure motor at M, and a motor generator at P. The directions of the currents and their superposition are clearly shown by the arrows in fig. 1 and by the diagrams figs. 4 and 5.

Fig. 4 represents the effect of the two currents superposed in series through the storage battery, motor M, and motor generator P.

Fig. 5 represents the effect of the two currents acting in parallel coils on a transformer, as shown at R; here the one current goes through the one winding, r, and the other through r^1, the other winding, but magnetising oppositely. The resultant effect is that of one alternating current, and is represented by the thick zig-zag line, C, in fig. 5. Thus the transformer business is provided for in this new method.

The fig. O represents double wound devices requiring constant magnetic excitement; here the two currents are magnetising in the same direction, so that their effect is represented by fig. 4; it is a superposed effect, and the magnetism is practically constant, hysteresis in the iron core largely contributing to effect a steady excitement.

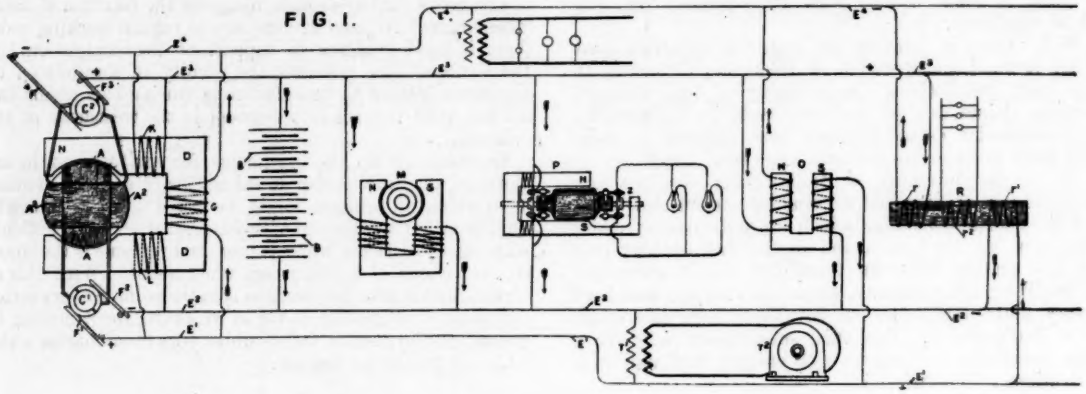
While hysteresis is a constant source of loss in alternating current systems, it is a decided gain in this duplex pulsating system, as upon its existence depends the steady excitement of magnetic devices.

At T and T^1 in fig. 1, are shown transformers worked by single pulsating currents; these, of course, would require to be open magnetic circuit transformers, and would also require to be so placed and connected that they would not disturb the equality of the currents in the two pulsating circuits.

The battery sub-station represented at B in fig. 1, would contain two sets of batteries, one charging at the time the other is discharging.

The motor generators (now called, very appropriately, dynamotors) can be operated in the series circuit, as represented at P in fig. 1. These machines are best constructed with only one high pressure circuit, namely, the motor circuit, of the armature; the field-magnets excited by a shunt and series winding connected to the secondary circuit of the dynamotor.

FIG. 1.



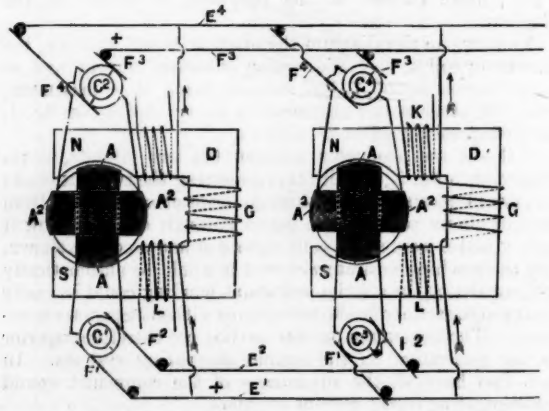


FIG. 2.

FIG. 4.

They can also be operated from the two pulsating circuits by having two high pressure circuits in the armature, one for each pulsating current.

By using single pulsating currents for transformer working, as represented at T, T^1, fig. 1, we get rid of the loss in transformers due to hysteresis, as there is no reversal of the magnetism. The iron cores of such transformers are necessarily open circuit cores, very short in length, short cores demagnetising much more rapidly than long ones.

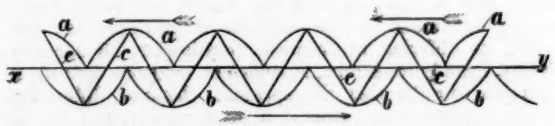


FIG. 5.

The transformers operated by the two pulsating currents, as represented at R, fig. 1, may have closed magnetic circuits with advantage.

(To be continued.)

RICHARD FRÈRES' PATENT ELECTRICITY METER.

[COMMUNICATED.]

THE meter of Richard Frères belongs to the class of intermittent integrating apparatus, and gives the indication generally supplied by meters, that is to say the product of the "energy consumed" by the "time," the reading in kilowatts hours being effected on the index hands with which instrument is provided.

The meter is composed of four principal parts;

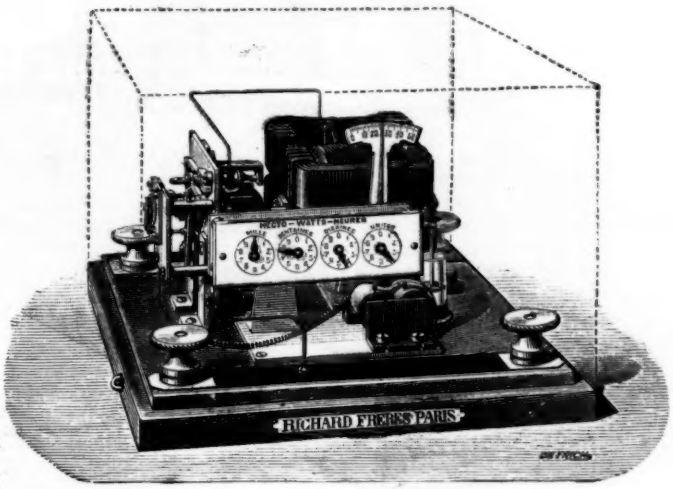
1. An electrically wound clock giving the time.
2. A wattmeter indicating the energy, E, C.
3. An integrating mechanism.
4. A totaliser with index.

A striking feature of the instrument is that the electric clock is distinct from all the other parts, and can be taken out by the mere unscrewing of five screws, and another put in its place by rescrewing the said screws, which operation takes less time to effect than to describe.

Whatever may be the system of meter used for the measurement of the electrical energy, the only part requiring periodical inspection is that giving the "time" factor.

However strongly built clock mechanism may be, and however certain its action, a time must certainly come when it requires cleaning.

But as in the majority of existing meters this part of the instrument is an integral portion of the whole if, for any reason, the said clockwork stops, it becomes necessary to bodily remove the meter and substitute another for it.



In the case of the Richard meter, the clockwork, entirely independent of the instrument, can be removed and replaced without in any way interfering with the lighting or giving the least trouble to the consumer.

The clockwork consists of a train of wheels, comprising three wheels, a spring, and either a cylindrical escapement or a conical pendulum. At regular intervals of 15 seconds, and by means of a very simple arrangement, the spring is strung and the clockwork motion defiles, regulated by the escapement.

The working continues with periodical winding up every 15 seconds. The stringing of the spring is caused by the action of the armature of an electro-magnet, through which a shunt current passes during the infinitely short period of winding up (0·02 second), the said period being regulated by means of two contacts acting in immediate succession, so that the break sparking does not occur at the winding up closing circuit contact. This arrangement keeps the winding contact in a desirable state of cleanliness, avoiding the effect of oxidation due to sparking, &c.

The winding up of the clockwork, occurring every 15 seconds, constitutes what is called the "period" of the meter. At the end of 10 seconds, the clockwork closes a second shunt circuit which circulates through the wattmeter fine wire coil.

Measuring Part.—The wattmeter is composed of a double frame of copper (wire or ribbon, according to the strength of the current), and in which the whole current passes. Inside the frame is a fine wire coil mounted on a spindle, one end of which is a pivot, the other end resting on a knife edge. The motor couple is equilibrated by means of a counterweight, which is preferable to springs. At the front end of fine wire coil's spindle is an indicating hand, and a wheel of the "crown" description, or "edged teeth," or otherwise "striated," and the action of which is hereafter described.

Integrating Part.—The integrating part consists of a little skin or India-rubber lined disc, mounted on a spindle, placed in the prolongation of the fine wire coil's spindle.

The said disc's spindle is contained between the two frame plates of the index, the wheels of which are actuated by a pinion mounted upon it. It is turned down at its two ends so as to be able to move backward and forward, the play allowed being about 2 millimetres. When at rest it is pressed home by a light spring, and, in this position, the padding with which it is provided is blocked against the striated wheel with which it becomes connected by friction.

The disc's spindle is actuated by the movable armature of an electro-magnet placed in series in the wattmeter's circuit. When a current passes through the wire of the electro-magnet, the movable armature pushes the spindle and its disc away from the wattmeter's clutch suppressing the connection which existed between the wattmeter and the meter.

The working is easy to understand. On the meter being placed upon a circuit the clockwork is instantly wound up and begins working. No current passes through the wattmeter fine wire coil, the hand of which remains at zero. At the end of ten seconds the clock causes a shunt current to circulate through the integrating electro-magnet and the wattmeter. The inertia moments of the electro-magnet's movable armature and of the fine wire coil being different the movable armature acts first and pushes the clutch forward. Instantaneously the wattmeter effects its measurement and the hand indicates the quantity of watts consumed.

At the end of the fifteenth second the clockwork is wound up, the circuit actuating the wattmeter being, at the same time, interrupted. The padded disc comes into contact with the toothed clutch of the wattmeter, which being no longer influenced comes back to zero. The disc follows this motion, and, therefore, turns an angle equal to the measurement.

Ten seconds later the wattmeter effects a new measurement, but without carrying the disc with it in its motion, since the latter is thrown forward before the fine wire coil begins moving; at the fifteenth second the latter falls back to zero, again carrying with it the disc through an angle equal to the measurement. The disc, and therefore the train of wheels of the meter's index, consequently turn of a quantity, equal to the sum of the angles corresponding to the measurements effected every fifteen seconds by the wattmeter.

The individual consumption of these meters is less than 2 watts, and they begin to indicate a consumption equal to the 0·02 of their power.

DIFFERENTIAL METERS.

It is easy to understand that as the motion of the integrating disc can take place in either direction, if the fine wire coil, and consequently its hand, is placed in such a manner that its displacement be from right to left with a current circulating in that direction and from left to right with a current of opposite direction, the meter so constructed will count in the first and discount in the second instance the consumption of current. It is therefore possible for the same price, and without any appreciable alteration in the meter, to satisfy the requirements of differential meters capable of measuring the energy stored in and discharged from a battery of accumulators. The apparatus lends itself to this, the more so that it can be provided with a mechanism such that by altering the resistance of the wattmeter when discharging the meter may discount, and at the same time take into account the percentage of loss, accumulators restituting a portion only of the energy previously stored in them.

If, for example, we suppose that the loss on discharging amounts to 10 per cent. of the E.M.F. and 10 per cent. of the C, or a total of 20 per cent., a resistance equal to 0·20 of that of the fine wire coil is placed in the wattmeter's circuit. A polarised armature placed along the thick wire frame causes the said resistance to be introduced in and withdrawn from the said circuit when charging and discharging respectively take place.

The charging measurement will be correct, whereas with an equal E.M.F. that of the discharging would be too great by 20 per cent., but as the efficiency is only 0·80 of the stored energy the index will be at zero when the battery is fully discharged.

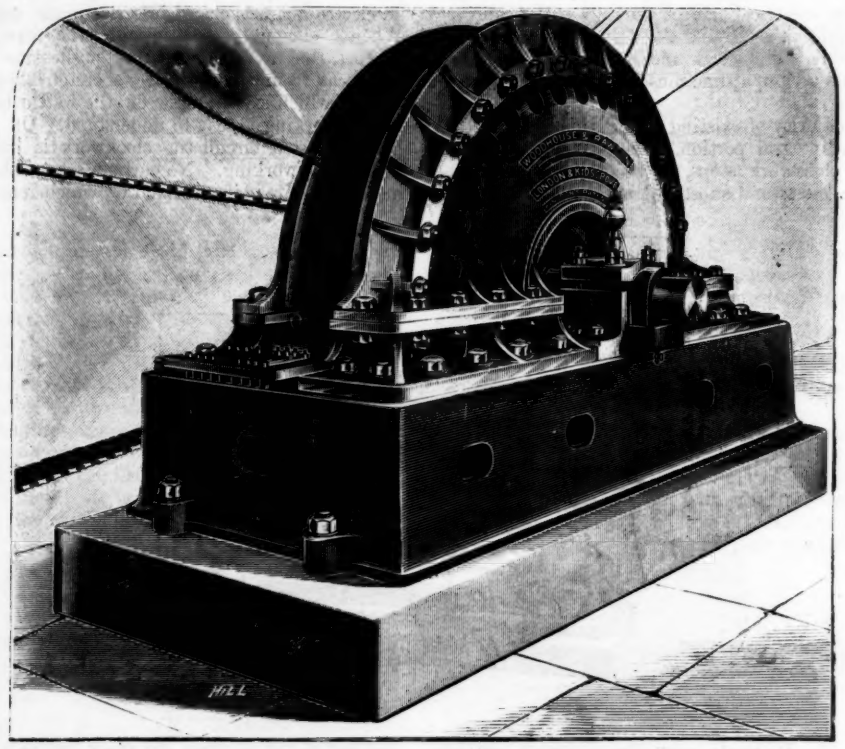
The percentages of any battery may be adjusted by correspondingly varying the percentage of the extra resistance.

In a recent pattern a mechanical process has been substituted for the electro-magnet above described and which when effecting the measure of the wattmeter throws forward the clutch; the said clutch is thrown into and out of gear by the action of the clock itself, the result being absolutely the same.

Ship Lighting.—It is said that no fewer than 15 steamers have been fitted out in the Clyde for the British India Steam Navigation Company with electric lighting arrangements.

THE KINGDON PATENT INDUCTOR DYNAMO.

OUR illustration represents a 70-unit alternating current dynamo designed by M. J. A. Kingdon for central station work, and used by Messrs. Woodhouse and Rawson United, Limited, of 88, Queen Victoria Street, London, E.C., for lighting their engineering works at Kidsgrove, Stafford. In this machine the coils which correspond both to the armature coils and to the field-magnet coils of an ordinary alternating current dynamo are fixed, while the revolving wheel carries a number of laminated masses of iron or inductors, which produce by their motion magnetic changes in the iron cores of the armature or secondary coils. The magnets of the dynamo are built up of a number of stamped iron plates of the shape shown in the diagram, and bolted between two stout circular cast iron frames divided horizontally along the centre line. The lower frames are bolted to a stout cast iron bed plate.



The inductor wheel is of exceptionally strong mechanical construction and consists of 16 inductors, which are constructed of a number of soft iron plates, insulated from one another, and bolted between two stout steel plates mounted on a hub keyed on to the main driving shaft. Between the inductors and steel plates are two brass rings which magnetically insulate the inductors from one another. The intermediate poles have their polarities constantly changed as the inductor wheel rotates, and alternating currents are accordingly generated in the coils with which they are wound.

There are no brushes or rubbing contacts, all the coils being fixed. The dynamo in use at Kidsgrove is wound with one set of coils for supplying incandescent lamps direct at 105 volts; another set is wound with high potential coils for transformer circuits, while a third set is used for arc lamps.

Two machines of similar, though slightly different design have been supplied by the company and erected at the Woking central station. These are wound for 30 ampères at 2,000 volts, and are coupled direct to triple expansion engines, which were also manufactured by Messrs. Woodhouse and Rawson United, Limited, at Kidsgrove.

THE ST. PANCRAS ELECTRICAL EXHIBITION.

WHEN, some time ago, a scheme was advanced by the Electricity Committee of the St. Pancras Vestry, for the inauguration of an electrical exhibition, in order to popularise the various applications of electricity among the parishioners, the only conclusion which could then be drawn was that such a demonstration would very probably be of an insignificant nature. That this idea was entirely erroneous is amply shown by the support given to the exhibition by many electrical firms. Prof. Henry Robinson, M.I.C.E., is the chairman of the exhibitors and the engineer superintending the exhibition, whilst the joint executive committee consists of Mr. A. Sweet, Dr. W. Smith, and Messrs. W. T. Hawkin, G. A. Hodgkinson and Chas. Wilson, representing the Electricity Committee; and Messrs. W. P. Miller, H. Bevis, A. T. Snell, A. Slatter and Strode, representing the exhibitors. Mr. G. E. Middleton being the secretary. Under the able management of these gentlemen, a very complete collection of electrical apparatus has been brought together—a collection which cannot fail to deeply impress upon the minds of the St. Pancrasites the importance of electricity as applied to lighting and power purposes.

At the private view of the exhibition—which is being held in the St. Pancras Vestry Hall—on Saturday evening last, Prof. Crookes, F.R.S., President of the Institution of Electrical Engineers, a number of ladies and gentlemen, members of the Vestry, and representatives of the Press, were present. On Monday the exhibition was formally opened by the Right Hon. the Lord Mayor, accompanied by the Sheriffs, and it will remain open to the 1st of April.

St. Pancras Road, in which the Vestry Hall is situated, is at best a dimly lighted street; but on Saturday evening a large Brockie-Pell arc lamp, carried on an iron standard just outside the hall, gave forth a sufficiency of light to indicate that something out of the ordinary way was taking place. On ascending the staircase and entering the large exhibition room, the visitors were much impressed by the brilliancy of the number of incandescent lamps installed, and by the completeness of the exhibition. The installation has been carried out by Messrs. Sharp and Kent in the remarkably short space of four days. The plant is arranged in the basement. It comprises a Marshall locomotive type boiler of 100 H.P., working at 140 lbs. pressure; two Willans engines of 80 H.P. and 20 H.P., and running at 300 and 7,000 revolutions respectively; a Goolden dynamo of 400 ampères and 120 volts; and a second machine giving 120 ampères at 120 volts; and a Worthington duplex feed pump. The dynamos are coupled direct to the engines, and there are five circuits supplying current to about 500 16-C.P. lamps, one of 500 C.P., one of 800 C.P., and two or three arc lamps. The lighting throughout is very effective.

On the occasion of the private view formality was dispensed with, and visitors circulated at their own sweet will. The representatives of the daily Press present were at first nonplussed, owing to the absence of any arrangement for their guidance and instruction, but after a little time had passed away two or three gentlemen kindly undertook to explain in the simplest of language the mysteries of some of the electrical exhibits. Then the countenances of the Pressmen, like the incandescent lamps, glowed, their minds were set at rest, and notes were rapidly taken, although previously they, Micawber-like, were waiting for "something to turn up."

The centre of attraction on Saturday was the telephones erected in one of the rooms by the National Telephone Company, Limited. The instruments were connected direct to the Savoy Theatre, where "The Gondoliers" was being rendered, the singing and musical portion being very audible. During the early part of the week the telephones have been connected with the Royalty Theatre in Manchester and with the Savoy Theatre during the latter days of the week. Berliner's gramophone also excites considerable attention, being exhibited by the General Electric Company, Limited.

Mr. Harry Thorpe, of 59, Theobald's Road, W.C., has on view his improved tubular electric light switch, electric light fittings in brass, nickel silver and bronze; various kinds of switches, motors, improved ringing apparatus for simultaneously operating any number of electric bells, semaphore indicator, telephones, switchboards, &c.

At the stand of Messrs. Miller and Woods, of 34, Gray's Inn Road, W.C., are to be found a variety of fittings, consisting of ordinary cord pendants, pendants with balance weights and for entrance halls, portable lamps, switches, fuses, shades, electroliers, ampère and voltmeters, Ader telephones, magneto-transmitters and receivers with battery call, and an Oerlikon arc lamp for parallel working with 50 volts.

Messrs. Latimer Clark, Muirhead & Co., of Westminster, exhibit, among other apparatus, portable galvanometers, Wheatstone bridges, standard mica condensers, resistances, volt and ammeters, house main switches as used by the St. James's and Pall Mall Company at the junction of the consumers' wires with the company's supply, samples of bare copper mains and culverts to be used for the St. Pancras parish, a Westminster dynamo of the W5 size, &c.

Messrs. Benham and Froude, of Chandos Street, W.C., have on view an interesting collection of electric light fittings in brass, copper, wrought iron, &c.; whilst the Acme Electric Works of Chalk Farm, N.W., show a variety of switches, ceiling roses, cut-outs, fuses, volt and ammeters, &c. At the stand of Mr. F. Geere Howard, of 18, Berners Street, W., are to be seen electroliers in brass, copper and wrought iron, brackets, pendants, extensible pendants with lamps alight, plain and ornamental shades, switches, &c. An exhibit representing the various methods of wiring and fitting up private residences and business premises, complete, and ready to be connected to a company's mains, is shown by Messrs. Illingworth Brothers, of 22, Ganton Street, W., together with different kinds of switchboards, electroliers, batteries, &c.

The General Electric Company, of 71, Queen Victoria Street, E.C., exhibit an electric pump driven by a ¼ H.P. motor and capable of throwing 80 gallons 100 feet per hour; an exhauster and blower actuated by a ⅛-H.P. motor, and having a capacity of 400 cubic feet per minute; Crocker-Wheeler motors, Aron electricity meters, registering volt and ammeters, electric water boilers and flat irons, bells, telephones, portable lamps for various purposes, cables, &c. An interesting model of their well-known water-tube boilers is displayed by the Babcock and Wilcox Company, of Newgate Street, E.C.

The enterprise of Messrs. Rashleigh Phipps and Dawson, of 53, Berners Street, W., is exemplified by the elaborate collection of electric light fittings on view. Among these may be mentioned the dipped and scratched brass fittings manufactured by the firm for the New Theatre in Manchester. They also exhibit a novel covering for incandescent lamp, called the patent lead ray diffuser, consisting of cut glass beads strung on silvered wire, the effect of which is to subdue and diffuse the light without decreasing it. The effect with either white or coloured beads is most charming, each bead flashing like a jewel.

The most attractive feature at the stand of Messrs. S. Z. de Ferranti, Limited, of Charterhouse Square, E.C., is a section of the Ferranti concentric cable which is now being used for transmitting current from the Deptford generating station to the Grosvenor Gallery distributing station at an E.M.F. of 10,000 volts. Several of the improved Ferranti meters for direct and alternating currents are also on view.

Messrs. Drake and Gorham, of Victoria Street, S.W., exhibit their improved "D.P." secondary battery Cardew voltmeters and earthing devices, switchboards, switches, fuse boxes, &c.

Messrs. Woodhouse and Rawson United, Limited, have on view an improved electric "Sun" lamp, by Mr. F. R. Boardman, various pendants, reading lamps, electroliers, telephones, bells, ammeters and voltmeters, shades, electric fans, motors, lamps, &c. The Keys Electric Company, Limited, of 122—124, Charing Cross Road, exhibit various dynamos, motors, arc lamps, &c., and also show the application of electricity to domestic purposes.

At the stand of the Planet Electrical Engineering Company, Limited, are shown a 400-C.P. Planet motor arc lamp, which is remarkable for the steadiness of the light, electric light fittings on post, volt and ampère meters, &c.

The General Electric Power and Traction Company's stand occupies almost the central position of the large room. Drills, fans, a meat-cutting machine, &c., are shown, operated by small electric motors, and the facility with which they can be started and stopped attracts considerable attention. An assortment of fittings, switches, lamps, &c., is also on view.

Messrs. A. B. Gill & Co. display a collection of cables, wires, lamps, electric light fittings, measuring instruments, arc and glow lamps, telephones, motors, portable lamps, &c.

Among other firms exhibiting are Messrs. Sharp and Kent, who show artistic fittings, switches, &c.; Messrs. F. and C. Osler, an imposing assortment of electroliers, pendants, standards, and brackets; Messrs. Richard Crittall & Co., a selection of electroliers, hall lanterns, pendants, shades, &c.; the Sunbeam Lamp Company, a number of Sunbeam lamps (one of 500 C.P. and another of 800 C.P. being alight), fittings, &c.; Messrs. Lacombe & Co., an interesting collection of arc light carbons, fluted carbons, batteries, carbon brushes, &c.; Messrs. Strode & Co., a display of electroliers, standards, hall lanterns, brackets, &c.; Messrs. Paterson and Cooper, Phœnix arc lamps, various kinds of fittings, portable lamp, electric motor operating a ventilating fan and another motor driving a sewing machine, measuring instruments, glow lamps, telephones, &c.; Messrs. Henry F. Joel & Co., two Joel slow-speed dynamos and a Joel motor, switchboards, Pilsen-Joel arc lamps, secondary and primary batteries, bells, fittings, &c.; Messrs. T. Potter and Sons, Limited, electric pendants, brackets, standards, table lamps, floor lamps, lanterns, &c., in iron, copper, and brass; Mr. Henry Conolly, a large assortment of fittings, electroliers, globes, shades, lamps, meters, electric bells, switches, &c.; Messrs. Engelbert & Co., a show case placed in the entrance lobby, and containing samples of various lubricating oils for engines and dynamos; Messrs. Caddy & Co., Limited, tubular chilled face smoke-consuming fire bars, specially adapted for high-pressure boilers used in electric light installations.

Amongst the exhibits there are so many demanding further description and illustration that we are compelled to postpone dealing fully with the exhibition till our next issue.

PARLIAMENTARY NOTES.

THE CENTRAL LONDON RAILWAY BILL.

THE Select Committee of the House of Commons, presided over by Mr. Hanbury, further considered the clauses of the Central London Railway Bill last week.

The CHAIRMAN, at the outset of the proceedings, enquired whether the promoters had anything to propose in regard to cheap fares or special facilities for the working classes, having in view the discussions that had taken place and the instructions that had been moved in the House of Commons.

Mr. FREEMAN (for the promoters) said they had amended Clause 63 of the Bill, with the object of meeting the view of the committee in regard to this matter. The clause as amended required the company to run two trains each way every morning—Sundays and holidays excepted—not later than seven o'clock, and every evening not earlier than six o'clock, at fares not exceeding ½d. per mile, the company nevertheless not being required to take any fare less than 1d. He asked the committee to bear in mind that the proposed line would

have to compete very seriously with the omnibus traffic; and, moreover, while the omnibuses paid nothing towards the local rates, this company would have to pay an enormous amount in the way of rates. As a company, they were in a different position to any ordinary railway company, because they did not destroy any rateable property, and he submitted that the clause they had put in went to the extreme of what they should be expected to do.

Mr. COURTENAY BOYLE (the Assistant Secretary to the Railway Department of the Board of Trade) was called by the chairman, and adduced evidence to the effect that the clauses dealing with workmen's trains which appeared in the Acts of other railway companies required the companies to carry workmen certain limited distances at the fare of 1d. per journey each passenger.

The CHAIRMAN remarked that the general rule appeared to be to charge 1d. each journey for short distances.

Mr. FREEMAN pointed out that the only line analogous to the proposed line was the City and North London Railway, and there was nothing in the Acts of that company requiring them to carry workmen the whole distance for 1d.

The CHAIRMAN enquired whether this 1d. per journey was a sum arrived at by rule of thumb, or whether it was based on any proportion to the ordinary fares.

Mr. COURTENAY BOYLE said it was a pure rule of thumb.

Mr. PEMBER, Q.C. (after consultation) said the promoters would be willing to run two workmen's trains each way, morning and evening, and agree to a maximum fare of 2d. for the whole distance from Shepherd's Bush to Cornhill.

The CHAIRMAN: I may tell you at once that that will do. We think you should fix the maximum fare at 1d. per journey for each passenger by a workman's train.

Mr. PEMBER: Surely you would not make that condition in the case of a line like this, which will cost £600,000 a mile to construct, &c.?

The CHAIRMAN: Yes. Pray remember the great concession you are obtaining from Parliament. I do not think we can allow you to go beyond 1d.

Mr. PEMBER said the idea of the promoters was a minimum of 1d., while the idea of the committee was a maximum of 1d. He thought it very hard that Parliament should, looking to the costly character of the line, call upon them to carry a passenger 6 miles for 1d. He did not think any case had been laid before the committee where only a maximum of 1d. was charged for 6 miles.

After some further argument,

The CHAIRMAN said the committee insisted on a fixed charge of 1d. per passenger for each journey by a workman's train. They also desired the clause to be amended so as to provide three workmen's trains daily, and to make it clear that the trains stopped at all intermediate stations.

The clause was accordingly amended to carry out the decision of the committee. A clause was also inserted, on the application of Mr. Pember, limiting the amount of compensation recoverable from the company in case of an accident to a passenger travelling with a workman's ticket to £100. A clause, proposed by the Marylebone Vestry, to prevent the soil excavated from the proposed railway being carried along Oxford Street between 10 a.m. and 6 p.m., was rejected. A number of clauses brought forward by the London County Council, were agreed to, and the Bill, as amended, was ordered to be reported to the House.

THE CITY AND SOUTH LONDON RAILWAY.

A Select Committee of the House of Commons, consisting of Mr. Hanbury (chairman), Sir George Campbell, Mr. F. Parker, and Mr. Halley Stewart was engaged on Saturday in considering the City and South London Railway (Islington Extension) Bill.

Mr. Pembroke Stephens, Q.C., and Mr. Rigg appeared for the promoters, and the opponents were represented as follows:—Gas Light and Coke Company, Mr. Pope, Q.C., and Mr. Dauckwertz; Lord Calthorpe, Mr. Saunders, Q.C., and Mr. L. Coward; Corporation of London, Mr. Littler, Q.C., and Mr. L. Monk; Commissioner of Sewers, Mr. Russell Griffiths; Messrs. Rothchild and Sons, Mr. Bidder, Q.C., and Mr. L. Coward; Metropolitan Railway, Mr. Littler, Q.C., and Mr. Worsley Taylor, Q.C., Counsel were reserved by the Vestry of St. Luke's, the Regent's Canal, City and Docks Railway Company, Cooper Brothers and Co., the Metropolitan District Railway Company, and the Union Bank of London.

Mr. PEMBROKE STEPHENS, in opening the case for the promoters, pointed out that the City and South London Company were the pioneers of the system of underground electric railways. Their line from the City to Stockwell had been constructed, finished, and opened at a cost of £225,000 per mile. That line was regularly opened for traffic on December 18th last, and while its working so far had been most successful, the promoters were satisfied that its full value and usefulness had not yet been reached. The line proposed by the present Bill would start in King William Street—a short distance from the present City terminus of the system—go underneath Princes Street, Moorgate Street, Finsbury Pavement, Finsbury Square and City Road, to near the Angel at Islington.

The CHAIRMAN: There is no actual junction with the existing line?

Mr. PEMBROKE STEPHENS: No; it had been thought better not to commence the new line actually at the existing terminus, but there would be a subway connecting the two stations, so that passengers could go from the one to the other without having to cross the street. The line would be built throughout of iron—stations as well as tunnels being af that material. The length of the line was two miles, and the stations would be at King William Street, Moorgate Street, Old Street, City Road (near Regent's Canal), and at a point a little short of the Angel at Islington, to be called Angel Station. The committee would see that the proposed line was clear away from any other line of railway; that at present there was no railway accommodation at all in the direction of Islington. Except for the fact that the subway would pass under the Metropolitan Company's line at Moorgate Street, it would not touch any other line at all. Notwithstanding the initial difficulties they had to contend with, the company had carried since they opened their line to Stockwell over 1,000,000 passengers, and that without any Sunday working. During the busiest part of the day they ran a four-minute service of trains, and they had adopted a system of fares which was quite unique—doing away with tickets and classification altogether, and charging the uniform fare of 2d. The additional capital to be raised, in order to carry out the Islington extension, was £660,000 of share capital, and £220,000 borrowing powers, making, altogether, £880,000. Referring to the petitions against the Bill, Mr. Stephens said Messrs. Rothchild's petition was mainly based on the fact that they were afraid they would be caused annoyance during the construction of the railway. The company's engineer, however, could give satisfactory assurances on this point. With regard to the petition of the Metropolitan Railway Company, it was not a fact that the new line would compete with them. The Metropolitan talked about the promoters of this Bill having some "ultimate object" in view, but it would be quite enough for Parliament to deal with this scheme upon its merits, without considering any "ultimate object." The chief grievance, however, of the Metropolitan appeared to be that this was not a steam railway, and that they, therefore, could not get any running powers over it. The Metropolitan, too, suggested that the promoters would ultimately drop electricity and resort to steam. This was rather a curious thing to say in view of the fact that the Metropolitan themselves were seriously contemplating last year adopting electricity as a motive power on their own line. In reply to a question by Sir George Campbell, Mr. Stephens stated that the estimate for works was £350,000, and there was an ample margin to meet any possible claims for compensation.

Mr. GREATHEAD, C.E., examined by Mr. Rigg, stated that the main object of the present extension was to afford to the very populous districts north of the City better facilities than they at present possessed of getting to the heart of the City. The reasons for not making a physical extension were both engineering and financial. If it were done, they would have to buy several buildings outright. When the authorised line from Stockwell to Clapham Common was carried out, passengers would be carried under cover all the way from Islington to Clapham Common. The station for generating the electricity would be at Duncan Terrace, Islington. The total cost of the works, including the purchase of the land and contingencies, would be about £558,402, and to that sum must be added £110,000 for equipment. That equipment would enable the company to run a three minutes' service. A two minutes' service would involve an additional outlay of £40,000 for equipment. The journey from Islington to King William Street would be performed in from 7½ to 8 minutes.

Mr. POPE, Q.C., and other counsel, entered the room for the purpose of cross-examining the witness. The Chairman, acting upon a rule laid down by him at the commencement of the proceedings, peremptorily declined to allow cross-examination by counsel who had not heard the examination-in-chief, unless some special reason could be shown for granting them the indulgence, and thereupon a number of counsel withdrew. Prof. Hopkinson and Sir Benjamin Baker were afterwards examined in support of the promoters' case, and the committee adjourned until Monday.

OVERHEAD WIRES.

A Bill promoted by the London County Council for the better regulation of overhead wires came last week before the Select Committee of the House of Commons, presided over by Mr. Stephen Williamson.

Mr. POPE, Q.C., stated that it was based on a report of a committee of the House in 1885, whereon sat the late Sir James McGarel Hogg, and the late Mr. Firth. The only change proposed was that the making of bye-laws and regulations should be entrusted to the council instead of to vestries and district boards. Opposition was entered by the Society of the Temple, who claimed exemption from the Act on the ground that they had no local authority; the Vestry of St. Giles's, and the Telephone Company. The Vestry of St. Giles's would prefer statutory prohibition of overhead wires altogether. The National Telephone Company urged that the proposed provisions would subject them to serious expense and great inconvenience in the conduct of their system. The Bill asked for power to the London County Council beyond that given by the Act of 1890 to the municipalities of large provincial towns for interference with overhead wires, which involve public danger or obstruction to the public in the use of the streets. The council asked for power to deal with other inconveniences which might arise, not necessarily involving danger or obstruction. After hearing evidence in favour of the Bill, the committee adjourned.

POSTAL OFFICIALS AND POLITICAL MEETINGS.

Mr. PICKERSGILL asked the Postmaster-General whether he was aware that on a bill advertising a meeting of Parliamentary electors at Sunbury on the 11th inst., and addressed by the hon. member for the Uxbridge division of Middlesex and other conservative members of Parliament, it was announced that tickets for reserved seats might be obtained on payment of 1s. each from Mr. Trotter, post office, Sunbury Common; and whether it was in accordance with the regulations of the service that postal officials and premises should be used for the advantage of a political party.

Mr. RAIKES: In reply to the hon. member, I have to say that I am aware that no such meeting as he mentions was addressed by the hon. member for the Uxbridge Division and other Conservative members, and that, in matter of fact, no such meeting took place at all. The

sub-postmaster of Sunbury Common assures me that his name was inserted in the bill to which the hon member refers without his knowledge or consent. The bill was not exhibited in the post office, but in the sub-postmaster's shop.

CITY AND SOUTH LONDON RAILWAY.

The Select Committee of the House of Commons, presided over by Mr. Hanbury, met on Monday for the purpose of hearing the opposition to the City and South London Railway Company's scheme for extending their system to Islington.

Counsel for several of the opponents, notably the Metropolitan Railway Company, were not present when the committee met, and, after about ten minutes' interval, Mr. Littler, Q.C., the leading counsel for the Metropolitan, was sent for.

The CHAIRMAN then informed Mr. Littler that in carrying out their rule limiting cross-examination the committee had been acting in accordance with a resolution of the General Committee on Railway and Canal Bills in 1861.

Mr. LITTLER retorted that that was an absolute rule which he could not subscribe to. He at the same time read a letter from the Metropolitan Railway, informing him that they were perfectly satisfied with the way they had been represented by their counsel, protesting against the ruling of the chairman, and instructing him to withdraw from the case if such ruling was persisted in.

The CHAIRMAN said the committee adhered to their ruling, and Mr. LITTLER thereupon withdrew from the case.

Mr. BIDDER, Q.C., announced that Messrs. Rothschild had arranged clauses for the protection of their property in the City with the promoters, and a similar announcement was made by Mr. DANCKWERTS on behalf of the Gas Light and Coke Company.

Mr. W. BARRY, C.E., gave evidence directed against the scheme, mainly on the ground that the line would not form part of any through metropolitan system.

After hearing counsel, the CHAIRMAN ordered the room to be cleared. On the readmission of the public, after an interval of 20 minutes, the Chairman said the committee did not consider that the preamble of the Bill had been proved. The Bill was accordingly rejected.

The Committee of the House of Commons, resumed the hearing of the evidence in case. At the commencement of the proceedings the Chairman intimated that, in the opinion of the committee, the weak point of the promoter's case was the awkward break between the already existing line and the proposed line at the Monument, and that the committee would require to be satisfied on that point.

Mr. RIGG stated that he would bear this in mind. Lord Calthorp had been settled with, and consequently his lordship's opposition had been withdrawn.

At a later period of the day Mr. Littler, Q.C., coming into the room during the examination in chief of Mr. Mott, the chairman of the City and South London Railway, enquired of the chairman whether he came under the committee's ruling of Friday.

The CHAIRMAN replied that he did not wish to apply it too closely, but that it was intended to be directed to a case in which neither senior nor junior counsel representing any party was present during the examination in chief of a witness, and desired to cross-examine, or desired to re-examine, not having been present during the cross-examination. As Mr. Littler had been present during part of the examination in chief, the committee would allow him to cross-examine.

Mr. MOTT was then cross-examined at great length, with a view to show that the line would not pay if made. Witness admitted that the existing line did not pay at present, although the stations and trains were crowded, but said that the crowding only occurred during two or three hours of the day.

Mr. BIDDER, Q.C., then cross-examined the witness as to the contract which formerly existed with Mr. Mather for the working of the line. The further cross-examination was directed to show that a site other than Messrs. Rothschild's Bank should be taken, particularly when alternative powers were taken over St. Swithin's Church and the Gresham Club, against which no objection had been lodged.

Mr. PEMBROKE STEPHEN said that the promoters would not press for compulsory powers over Messrs. Rothschild's property.

By Mr. RUSSELL GRIFFITHS: It would not be possible to have a physical junction between the existing line and the proposed line under King William Street, as the gradient, being 1 in 14, would not permit of it, although Mr. Greathead, the engineer, had admitted in evidence that it would be desirable to have such a physical junction rather than the subway for passengers only. He hoped that the line would cost less than £440,000 per mile, which was the figure of the estimate.

Re-examined by Mr. PEMBROKE STEPHEN: In his view it was desirable to have a thoroughfare from Stockwell to the Angel, and they did not propose to make any alterations in that respect.

By Sir GEORGE CAMPBELL: There was just as good security as in the other cases that if the Bill was passed the line would be made.

Mr. GREATHEAD, the engineer, was then recalled, and explained to the committee the enormous difficulty and immense expense which would be involved in the making of a physical junction at King William Street; otherwise he would have liked a physical junction.

The CHAIRMAN: Then you are in direct conflict with Mr. Mott, the chairman of the company.

Mr. RIGG: Mr. Mott has to find the money, and Mr. Greathead only has to carry out the scheme.

Sir JOHN FOWLER having given evidence in support of the Bill, the committee adjourned.

THE ELECTRIC ARC AND ITS USE IN LIGHTING.*

BY ELIHU THOMSON.

IT is curious that notwithstanding the fact that as a source of illumination the electric arc has been known since the beginning of the century, the scientific study of its nature has been but little pursued. It began to be known as a sort of scientific curiosity, being at first set apart as one of the many phenomena observed in the use of powerful batteries. It was not until about 20 years after its discovery by Sir Humphrey Davy that any proposals were made to use it in lighting, and, subsequently, for many years it was occasionally employed either in lecture demonstrations or in obtaining an intense light for some special purpose.

The efforts to use it in lighthouses led to the designing and construction of machines on the magneto-electric principle to replace the cumbrous and costly batteries otherwise required. I remember vividly the hours of labour and time necessary to prepare a battery of 40 Bunsen cells for use in working a single small arc light for, at most, two or three hours. But I remember far more vividly the suffocating fumes and risk of acid spilling, with accompanying ruin concomitant on the taking down of a partially exhausted battery. Even to work with the arc for an hour or two was, however, adjudged a sufficient compensation for the disadvantages in obtaining the current. All this has, however, been changed, and the past 10 or 15 years has made the arc as a source of illumination one of the indispensables of a progressive community. Instead of the original, little short sticks of wood charcoal used as "points," which were only "points" because it was not expected that the arc would be burned for more than a few minutes without exhausting the battery, there came later on the little hard carbon sticks about 2 inches long and $\frac{3}{16}$-inch square, sawn from hard gas-retort carbon, or from battery plates; and, lastly, came the moulded and forced carbons made from a paste in a powerful press, millions of which are now required every week to keep the lamps at present in use supplied.

The charcoal points of Davy were touched together horizontally after attachment of the wires to the battery, and were then separated. The stream of hot flame which followed or joined the points being deflected by air currents took the form of an arch or curve which gave the name to the phenomenon. Even with one carbon directly over the other, the curved form of the stream is the rule when the carbons are widely separated. Davy's original experiment was made with a battery of 2,000 cells, with zinc and copper plates about 6 inches square, the exciting fluid being very dilute sulphuric and nitric acids.

Davy's description is as follows:—"When pieces of charcoal about an inch long and one-sixth of an inch in diameter were brought near each other (within the thirtieth or fortieth part of an inch) a bright spark was produced, and more than half the volume of the charcoal became ignited to whiteness; and, by withdrawing the points from each other, a constant discharge took place through the heated air in a space equal at least to 4 inches, producing a most brilliant ascending arch of light, broad and conical in form in the middle." This was evidently a long, flaming, and horizontal arc. I find this form shown in a book published as late as 1846: Davis's "Manual of Magnetism." Indeed, I know of no more forcible example of the persistency of old ideas than is afforded by the accounts given in the books concerning the nature of the electric arc. The persistence of old cuts is also equally exemplified, even down to the latest publications, giving pictures of the electric arc. The carbons are generally shown crusted over with dense masses of impurities melted into globules and adhering to their sides Such figures would not now be recognised as resembling arcs formed with good, pure carbons, such as must be used for commercial results in arc work.

In regard to the ideas put forward as to the nature of the electric arc there is even a wider divergence than in the figures used for representing it. But these views are remarkable for their general inaccuracy or crudity, and evidently

* Read before the National Electric Light Association, February 18th, 1891.

have been handed down with modifications. Few of those who have written about the electric arc, at least in the text-books, seem to have had the courage to look at the arc, or they may have seen it "through a glass darkly and not face to face." It would require too many and lengthy quotations to give these various views. In most of them the light of the arc is attributed to intensely heated carbon particles transported by the current from one pole to the other. In most of them the idea of carbon vapour as a possible factor never seems to have arisen. Others attribute the arc to the heated air between the carbons which carries carbon particles, some of which are burned.

The following quotation from a book on electric lighting, published in 1884, is a type of many such accounts :—

"In arc lamps, as we have already stated, the resistance which converts the current into heat is that of the heated air between the ends of two carbon rods, from one to the other of which the current passes. The light is produced by the incandescence of the ends of the carbon poles, and of the minute particles of carbon which become detached and float in the heated air between them. The heated air containing the particles of carbon forms what is called the electric arc."

Here the heated air and carbon particles floating therein are definitely stated to form the "electric arc." Nothing is said of carbon vapour having anything to do with it.

Even the statement that the positive carbon burns twice as fast as the negative is very frequently found unqualified in any way whatever. The experience of the lamp trimmer is, I need scarcely say, not in accordance therewith, the fact being that the rate of consumption even in direct current arcs with the same size carbon in both holders varied sometimes quite widely from the proportion stated. However, we shall make better progress if we discard at once the older notions, and, adhering only to that modicum of truth which often accompanies error, supplant the error by the results of our own observations and experiments. My endeavour will, therefore, be to state as briefly as I can such views of the nature of the electric arc as seem to be borne out by observation during many years, and under greatly varying conditions of its production.

Let an attempt be made to separate any part of a circuit in which the current is maintained by a sufficient E.M.F. or potential, and we find that if the separated ends are moved quickly we get a flash or spark of varying length which becomes a flame of great heating effect if the current be of large rate of flow. If the separation of the two parts of the circuit be made slowly a continuous flame or discharge will take place between the ends if they be not too widely separated or not so widely separated that the potential or pressure of the current is insufficient to force current across the space. With considerable potentials and heavy currents a space of many inches may thus be bridged. Whether the separated ends be of iron, copper, carbon, platinum, zinc or other conductor, the hot discharge is still formed. Therefore while the electric arc is generally spoken of as that flux occurring between *carbon* ends separated, of course it can not be so limited, and we frequently, therefore, refer to copper arcs, iron arcs, carbon arcs, to distinguish one from the other. What then is the arc so formed? Is it heated air between the ends separated containing detached particles of the conductor in process of carriage, as was apparently thought for a long time to be the case? No, the arc proper is composed of a stream of vapour arising from the actual boiling or vaporisation of the solid or fused ends of the separated conductors. In so far as the surrounding air mixes or combines with this vapour stream it is modified by the presence of oxygen and nitrogen, but the air or any other gas is not essential to be present and is merely incidental to the formation of the true arc stream in air. Indeed it may seem strange to some to speak of vapour of carbon, copper, iron, platinum, &c., but their production is merely a question of temperature in any case. In the electric arc there is a real distillation of the conductor forming it, and this accounts for the variation of colour and temperature to be found in different arcs. The copper arc evolves a peculiar green light which is exceedingly trying to the eyes, those who have experienced its effects well know. Zinc gives a whitish blue, while the carbon arc proper is purplish in tint. The arcs from various metals give in the spectroscope the characteristic lines of the vapour of each metal.

As a curious incident, showing the presence of the metal vapour in the arc, I may mention the fact that when by accident a person has had a portion of his clothing bathed for an instant in a heavy copper arc caused by a short circuit of heavy current mains there has been found a considerable deposit of copper, enough, in some cases, to give the reddish colour of copper to the surface bathed, which, if moistened, turns green by oxidation. It also gives a deep blue to dilute ammonia in which it is washed, thus showing the presence of copper. In like manner these metallic arcs will give a deposit of the metal on cold surfaces which they touch.

It appears to be the positive pole which gives out the vapour stream. With carbon the positive vaporises steadily and is consumed much faster than the negative. In the use of the arc, however, for lighting, we have learned to distinguish between what is called a "short arc" and a "long arc" system. In short arc systems the carbons are burned much nearer together than in the "long arc" systems. Let us suppose the case of two carbons touching each other with a current passing and then that we very slowly separate them, stopping to observe effects. When the contact is light before actual separation, a visible heating in the meeting ends is seen. On attaining a small separation the space between seems filled with hot vapour, and we have a short arc where the separation is perhaps not over 2 to 3 one-hundredths of an inch. There is also noticed an active transfer of carbon from the flattened end of the positive and a deposition of carbon on the end of the negative carbon. This deposited carbon takes the form of a mushroom end after a time, and breaks off. Meanwhile combustion goes on at both poles and wears away the side of the positive carbon while the transfer of carbon wears away the tip or crater. The burning also wears away the negative at the sides, while the tip is built up by the mushroom deposit from the arc. But the cutting in of the negative finally severs the mushroom tip and it falls away. Hence both carbons are eventually consumed. To develop a short arc there is required a little over half the potential that is needed for a "long arc," or about 25 volts more or less, and therefore to give out equal heat energy in the arc the current must be double in the short arc over what it would be in the long arc. The short arc is subject to the objection of a continual frying sound emitted and great variations of luminosity; it requires a very dense and hard carbon to conduct the current without great loss, and involves line loss of at least four times the amount with the long arc if equal gauge wires be used.

In fact, while in the past such arcs were common, their number is diminishing, as they are being replaced by the more efficient and completely developed arcs called "long arcs," which are so called to distinguish them from the "short arcs." Returning to our separating carbons we find that as the space of arc is lengthened from the short arc condition, we pass a stage of great flickering and unsteadiness and a fluctuating potential between the carbons, and then reach the stage of production of the long or quiet arc. With 10 amperes the separation may now be about $\frac{1}{16}$th to $\frac{1}{10}$th inch or more. Smaller currents require less separation and larger ones an increased separation. At this stage the arc is quiet, with good pure carbons very steady, and the potential difference remains at about 45 volts, if, of course, the carbon is properly fed to make up for combustion. The perfect arc is really a beautiful phenomenon. While the positive carbon still loses by volatilisation from its tip or crater and by combustion from its sides, the negative gains no deposit but wastes at a less rate than the other, and by combustion only. The carbon vapour carried off from the positive is consumed by the oxygen of the air before it can deposit on the negative. Hence the outer zone of flame, which can easily be distinguished from the central zone or arc flux proper, is probably a zone of combustion similar to that existing in ordinary flames. The removal of carbon by vaporisation from the positive end gives rise to the crater or cup which is so prominent a feature of carbon arcs produced by continuous currents. The size or area of the crater is a rough measure of current strength but varies with different qualities of carbon. With very long arcs the crater or hollowed end disappears and the ends become rounded. A well formed crater with the arc or flame confined thereto means usually a steady light, since the chief source of light in an electric arc is from the positive crater which shines like a diminu-

tive sun and represents the hottest part of the arc. The vapour light proper, or flame light, is comparatively very feeble and of a purple quality in air. Hence the arc light is as truly an incandescent source of light as is the incandescent carbon filament, with the difference that to run the latter at the temperature of vaporisation or boiling point of carbon, so to speak, means instant destruction, while by the necessities of the case the light obtained from the arc is chiefly that emitted from a surface of carbon at its temperature of boiling, or more correctly of sublimation at atmospheric pressures. This temperature is exceedingly high, and accounts for the well-known superior economy in light production of the arc over all other kinds of lighting. The temperature of the positive carbon crater is so high, that the carbon exists there in a soft or plastic condition, capable of receiving an impression like putty. I have proved this with very large arcs of 150 to 200 amperes, by suddenly forcing the carbons together when the current had been cut off, and finding that they would fit each other perfectly, the negative impressing its form on the positive crater.

As an interesting fact in this connection, I may state that I have been able to bend carbon sticks of $\frac{3}{16}$ths to $\frac{1}{4}$-inch in diameter by passing current through them of sufficient amount to almost vaporise the sticks, and cause them to emit an intensity of light approaching that of the arc.

These facts would point to the possible fusion of carbon into liquid carbon at arc temperature under a high pressure of inert gas. No one has as yet seen carbon in this liquid condition, and the electric arc alone has made us acquainted with carbon vapour. One cannot fail to be impressed with the fact that the conveyance of carbon in the arc has a striking resemblance to a plating process where metal is taken up by the bath from the positive plate, and deposited on the negative. In the arc the hot vapour stream or flame takes the part of the bath, and probably acts by molecular interchanges of carbon atoms in molecules of carbon to cause the transfer which occurs, just as in the plating bath the molecules of the plating compound are polarised and allowed atomic interchange, which results in conveyance of metal through the bath.

Another curious fact in relation to the arc is the distribution of potential in it. Dr. J. A. Fleming has recently shown that the difference of potential between the positive carbon and the arc flame is about 40 volts, and the few volts which express the difference between the flame and the negative make up the total potential, say, 45 volts. Hence the real work of the arc is not in the flame; the energy is not used in overcoming flame resistance, but chiefly in vaporising carbon in the positive crater. It is certainly not strange that with 40 volts, and say, 10 amperes, or 400 watts expended virtually at the crater surface of the positive carbon, the temperature and luminous effects should there be so great.

The distribution of potential in the arc just noted was also brought out about the year 1884 in some testimony in an interference in our patent office concerning an arc lamp cut-out which I had invented, and which took advantage of the potential differences between the carbons and the arc flame to cut out the lamp when the arc was too long. It is of course well known that the value of an arc light for general illumination is greatly enhanced by the fact of the distribution of light being mainly in a downward direction in continuous current arcs. This of course follows from the fact of the positive carbon crater being above, such crater being the part from which most of the light comes.

This matter has been quite thoroughly investigated, and many diagrams of distribution are to be found in the literature of the subject, as published from time to time. They show that with the long arc the maximum intensity of light is from 40° to 60° downward from the horizontal, and that the horizontal intensity is generally much less than one-half as great, while of course the intensity diminishes above the horizontal direction and ultimately becomes zero before reaching the upward vertical direction. In like manner the approach to the downward vertical from the direction of maximum intensity is attended with similar rapid diminution.

The spherical candle-power of arc lights would therefore be only a fraction of the rated candle-power, which is generally taken at the maximum light obtainable in the best direction from the particular arc or kind of arc in question.

For this reason the term 2,000 C.P. arc has little significance as indicating the illuminating power of an arc. It is a convention only and a poor one at that. It is now generally taken to mean an arc with 10 amperes and not less than 45 volts potential difference between the carbons, or a 450-watt arc. The quality of the carbons will determine whether the 450 watts will be expended in obtaining the most light or not, or whether that light will have a maximum intensity at one angle or another within certain limits.

When arcs are operated on by alternating currents, the effects mentioned are only partially exhibited, and the phenomena of the crater are of course masked or obliterated on account of reversal of function of the carbons. Unless the alternations are rapid, such arcs are liable to extinction at the zero points of current, particularly when run in a draft of air. A strong draft of air or a displacing magnetic field may of course so disturb an arc as to cause its extinguishment.

In the early years of the growth of arc lighting as a means of illumination, the effects obtained were not of the best. Unsteadiness was the rule, and it required much persistent effort to discover the causes and find the remedy.

The prominent defects were, and, we may add, are still, hissing, sputtering, flaming, and general unsteadiness. Hissing or frying comes, of course, with too short an arc, and may be connected with too vigorous vaporisation. They may also be due in some cases to a carbon of too coarse a grain. Sputtering may arise from impurities in the carbons, and flaming from too long arcs from impure carbons, or from carbons insufficiently baked and containing unexpelled gases. Running an arc at a length between the long arc condition and the short arc condition may cause great unsteadiness of light. There is, in fact, a critical point in the length below which there is a considerable fall of luminosity and a drop of nearly one-third of potential. As an arc lengthens by combustion of its carbons beginning below this critical point, great unsteadiness will be manifest on arriving at the critical state, and a little longer arc brings about a sudden and very marked increase of potential, of illumination, and of steadiness.

Any observer may easily detect these conditions without special effort. The earlier carbons used with arc lamps in the United States were both badly conducting, impure, and badly made. Copper coating was a necessity. French or Carré carbons were much better, but were too costly to import. The use of the petroleum carbon or the carbon obtained by the carbonisation of the tarry residue left in the distillation of crude oil, made a wonderful difference in the purity of the carbons, and improved machinery gave accuracy of form and cheapness. To one familiar with the former cost of carbons for battery arcs the reductions in cost are very striking: carbons $\frac{3}{16}$-inch square cost a number of cents an inch before the year 1878.

Another important matter in relation to carbons is that the size of section or diameter must be proportioned to the current used. Where attempts have been made to prolong the hours of burning of a carbon by enlarging its diameter beyond certain limits, they have resulted in injury to the character and distribution of the light. Large diameters of carbon may burn too blunt to let the light out between them.

Likewise, where attempts have been made to prolong the hours of use by employing a harder or denser carbon than before, it has frequently been found that a sacrifice of light has been incurred, rendering the results much less satisfactory.

One of the chief obstacles to the employment of quite small arcs with currents of 3 or 4 amperes is the difficulty of obtaining suitably uniform carbons.

Arcs of even as low as 2 amperes at 45 volts are easily produced, and such small arcs might even have commercial utility if the difficulties in relation to carbons were removed. An arc consuming 90 to 100 watts means, of course, about 7 or 8 to the electrical horse-power.

On the other hand, very large or heavy current arcs are difficult to control. They are apt to be unstable at times, and when they get to hissing, or rather roaring, it is difficult to restore quietness and steady action. The introduction of cored carbons for the positive has, however, done much to remedy the difficulty, and, indeed, to render it possible to

obtain very unform results from arcs in general, wherever such results are indispensable. The introduction of the central soft core into the carbon seems to locate the arc centrally, hold it from fluttering or shifting its position on the end of the positive; in other words, the core fixes the position of the crater, and so benefits the light.

It follows from the fact that the voltage required to sustain an arc with large or small currents ranges about 45 to 50 volts, that the larger the current passing in an arc, the less its electrical resistance. Hence well developed arcs, with 4 ampères, will have about 11 ohms, with 10 ampères, 4·5 ohms resistance, and with 100 ampères, ·45 ohms. This fall of resistance, with increasing current, is easily explained by the broadening or thickening of the arc stream, and the widening of the crater on the positive carbon. This widening of the crater also gives increased illuminating power, without increase of temperature. It is probable that the actual crater temperature is as great in the small arcs as in the large ones. In fact, this is implied by the quality of the light remaining the same. Nevertheless, the larger the arc, the greater the economy, or the greater light-giving power per unit of energy. This would naturally be expected, as the concentration of heat and lessened chances for escape of heat by convection and conduction would conduce to that result.

The fall of resistance, with increase of current, has an important bearing on the construction of dynamos for arc lighting and the running of lamps on constant potential or incandescent circuits, and will be referred to later on. Attempts have been made at various times to save carbons in arcs by excluding the oxygen of the air, which is the cause of their waste or consumption by burning. The gain has not apparently compensated for the disadvantages incurred, particularly as the total exclusion of oxygen means that the carbons become blunt. They would be prevented from pointing themselves or acquiring tapered ends by burning, a condition essential to good working and distribution of light. Even when the arc is formed in a vacuum, the carbons, though not burned, are slowly consumed, and carbon deposited as a soot on the sides of the vacuum chamber, an effect consequent upon the vaporised carbon in the arc being carried off and condensed again as soon as the vapour escapes the heat of the arc stream.

In fact, I have found it possible to coat objects on the inside of a bulb with silver or other metals volatilised suddenly by arcs in vacuo, and have obtained in some cases coherent brilliant deposits. The metal is raised in vapour as a metallic arc, and distills and condenses on the surfaces near at hand.

(*To be continued.*)

THE ELECTRIC LIGHTING OF SOPHIA.

[FROM OUR OWN CORRESPONDENT.]

THE city of Sophia has resolved to erect a large electrical establishment on its own account, and has just drawn up a schedule of conditions under which tenders are invited for furnishing the requisite arrangements.

Sophia is—as the schedule expressly states—a rising city in the course of a thorough metamorphosis. It has risen within a relatively short time from a mere village to a very considerable town, and it cannot be at present calculated how far the rapid and continuous development of this energetic and progressive town will extend. With reference to this circumstance, the projected electric works must be so arranged that they may have at the outset a capacity sufficient for the present stage of the town's development, but that from the beginning they must admit of the possibility of successively extending the works, by the simple addition of new machines and the extension of the conductive net, to a capacity sufficient for the probable future extent of the city.

For this purpose the municipality of Sophia has taken into consideration the utilisation of the water-power on the mountain Vitoche at the distance of about 10 kilometres, where two streams are to be united by a canal and led into an artificial reservoir of the capacity of 27,000 cubic metres. According to calculations executed by the technical organs, the union of the two streams will, at the present level of the water, give a minimum supply of 104 litres per second. It is also possible at the intended site of the electrical works to attain a fall of 708 metres. The water supply is constant, and there is no fear of freezing.

By the utilisation of this water-power there can be secured an available motive-force of at least 2,200 H.P., and this capacity is taken as the limit which the electrical works may reach in time. The high fall necessitates a special construction of the turbines, and in the schedule of conditions particular emphasis is attached to the substantial construction of these appliances. As regards the details of the execution, no prescription is imposed upon the parties tendering.

With regard to the great distance between the site of the works and the city, the use of alternating-current machines with transformers is characterised as advantageous, but parties tendering have the option of proposing other systems of distribution, always provided that such systems afford the necessary security for economy and regularity of work.

Tenderers are also at liberty to make offers based upon the use of steam-power, provided that the advantages thus obtainable outweigh those of the economy of water-power. But this possibly may be with right regarded as excluded, as Cardiff coal costs 60 francs per ton delivered free at Sophia.

The leads from the works to the circuit of the city are to be bright copper wires. Within the city itself underground cables are to be laid. In calculating the leads, it must be remembered that all the squares, streets and lanes at present built are to obtain the electric light, and the possibility must be afforded that with the increase of the town and the growing demand for light, it may be easily and cheaply supplied in new quarters.

All the main streets are to be lighted with arc lamps, whilst for the side streets, glow lamps are proposed. The street lamps are divided into two classes with respect to their time of burning, so that those of the first class may serve from evening twilight to midnight, whilst those of the second class are turned off at 10.30 p.m.

Otherwise the schedule of conditions is so drawn up that it concedes to parties tendering the greatest possible liberty for their arrangements, and it will then be the task of the municipality to seek out which tender is best adapted to the circumstances of the city and offers the greatest advantages.

The electrical works must be completed within at most two years from the conclusion of the agreement. Tenders must be handed in not later than July 1st (Old Style), 1891.

THE LONDON AND PARIS TELEPHONE.

ON Wednesday we had an opportunity of trying the speaking capacity of the new line connecting London with Paris, and we have no hesitation in pronouncing it, at the outset, an unqualified success, although when experiments with other transmitters and induction coils have been carried out, the results may be even better.

The total distance from London to Paris is 297 miles by the route the wires follow. Each wire for the telephonic service consists of 83 miles of copper wire weighing 400 lbs. per mile between London and St. Margaret's Bay, near Dover, the landing place of the cable on the English side. From this point to Sangatte, near Calais, the French landing place, a special form of cable has been laid, consisting of four conductors, each composed of a strand of seven copper wires; each stranded conductor weighing 300 lbs. per knot. The dielectric is gutta-percha, weighing 300 lbs. per knot, and the length of each conductor is approximately 21 knots. (For full description see Mr. Preece's B.A. paper, published in the REVIEW, on September 12th of last year.)

The wires from Sangatte to Paris are also of copper, weighing 600 lbs. per mile, the distance between these two points being 190 miles.

The electrical resistance of the conductors is as follows:—Aerial wire, London to St. Margaret's Bay, 2·25 ohms per mile, or a total of 186·75 ohms; cable, 7 ohms per knot, or a total of 147 ohms; aerial wire, Sangatte to Paris, 1·5 ohms per mile, or a total of 285 ohms.

The electro-static capacity of the overhead wires is ·015 microfarads per mile, and that of the cable is ·27 microfarads

per knot. The total electrical resistance between London and Paris, is therefore 619 ohms, and the total electro-static capacity is 9·765 microfarads, which gives a total K.R. of 6044.

The following complimentary messages between the Postmaster-General and M. Jules Roche, Minister of Commercial Industry and Colonies, exchanged over the new telephone line to Paris.

Monsieur le Ministre,—Permettez que je vous offre mes salutations et félicitations.

Le triomphe de la téléphonie internationale est un fait accompli. Il a été réservé à la France et l'Angleterre de mettre le sommet aux efforts de la science télégraphique et téléphonique.

Le génie et l'habileté de nos ingénieurs sont couronnés de succès.

La France et l'Angleterre alliés par l'estime mutuel, les intérêts communs, dès aujourd'hui sont alliés par l'agent humain le plus puissant—la voix humaine. C'est à l'aide de cet agent que j'ai l'honneur de bien vous saluer Monsieur le Ministre. Séparé par près de trois cent milles de terre et de mer, je vous assure de vive voix de mes sentiments les plus cordiales et sincères.

Reply of M. Jules Roche, Minister of Commerce, Industry and the Colonies.

Je vous remercie Monsieur le Postmaster-General, des sentiments que vous venez de m'exprimer et que j'éprouve moi-même avec autant de sincerité que de vivacité. L'inauguration à laquelle nous procedons en ce moment est un fait également considerable dans l'histoire de la science et dans celle de l'industrie, et le succès de l'enterprise hardie qui vient d'être accomplie si heureusement après des épreuves si dramatiques qui ont mis en péril la vie des ingénieurs telegraphiques de nos deux pays en même temps que celle de vos marins fait le plus grand honneur à l'Angleterre et à la France. Je me rejouis profondement devoir nos deux Gouvernements et nos deux nations unir leurs efforts pour une œuvre commune de paix et de progres aussi important que celle qui vient de rapprocher à portée de la voix humaine les deux plus grandes capitales du monde les deux villes où la puissance du génie humain se manifeste par les plus éclatants et les plus divers témoinages, Puisse ce nouveau miracle de la science asservissant aux besoins de l'homme les forces de la nature être un lien plus étroit entre deux nations déjà unies par tant de motifs d'estime et d'affection réciproques. Au nom du Gouvernement et du peuple de France, j'envoie au Gouvernement et au peuple d'Angleterre, le salut le plus cordial et les vœux les plus sincères de concorde et de prospérité commune.

The Postal Telegraph Officials, both English and French, are to be heartily congratulated on the accuracy of their calculations for ensuring good talking, but we feel that Mr. Preece and his able assistants must deprecate the fulsome flattery which the daily press has showered upon them.

The new line is understood to be open to the public on April 2nd (is the 1st too ominous a date ?) at 8s. for three minutes' conversation. At the beginning only one circuit will be employed, but the second will be put into operation should business necessitate it. The instruments to be ultimately employed have not yet been decided upon, but in any case success has been achieved, and Mr. Preece has now the satisfaction of having practically proved the theoretical conclusions at which he had arrived nearly a year ago.

NOTES.

Bradford Tramways.—With reference to the paragraph that appeared in last week's issue, we understand that although the tramways committee wished to have full information placed before them regarding both the overhead and underground systems they did not approach the subject with unbiassed minds, and the objections that were entertained against the overhead system were strengthened when the detailed plans and estimates were placed before them. It was found that either with a central line or with two-side lines of poles for the overhead system, a very considerable interference with street traffic would take place, Wakefield Road, where the new tramway is to be laid, being a narrow and busy thoroughfare. Moreover, an overhead system could not be tried experimentally, because, in the event of its proving unsuitable, there would be much expense involved in re-opening the street for the purpose of laying down an underground cable. Again, the corporation have laid it down that the Post Office and telephone companies shall not place poles in any of the streets that converge upon the business centre of the town, and presumably they have no desire to set a bad example.

Barker's Improved Insulator.—The object of this invention is to provide means for increasing the insulating power or properties of all kinds of insulators used for electrical purposes, and, further, to prevent what is known as "chattering," or, in other words, the movement of the wires where attached to their insulated supports, caused by the vibration of the intervening lengths of loose wire. In order to accomplish this end Mr. Barker inserts, either into the existing ordinary groove or into a groove of special size and shape, a ring or washer of some such insulating and elastic material as India-rubber, upon which seat or cushion the wire is bound, instead of as heretofore upon the bare surface of stoneware, porcelain, glass, &c. This ring or washer may be so constructed as to either leave the wire bare or by turning over it after it is bound in the groove cover its whole surface, except where it leads into and out of the insulator. These extra insulating and elastic rings or washers may be made in various ways, shapes, and kinds, and of various materials, but the kind preferred is one made of moulded and vulcanised India-rubber, having a square base to fit into a square recess in an insulator, and having a semi-circular concave recess or groove for the binding wire. The points of novelty claimed are :—The employment of India-rubber, a fixed or movable elastic insulating washer or ring outside any insulator, and between it and the electric wire. A novel means of insulating electric currents and obviating chattering. Mr. Barker's device, which is manufactured by Price, Sons and Company, may be of great service in the latter respect, but he must not think that the insulation will be improved.

Yacht Lighting.—The electric lighting of H.S.H. the Prince of Monaco's yacht *Princess Alice* has been placed in the hands of Woodhouse and Rawson United, Limited. The engine is of the single cylinder vertical type with a steam pressure of 150 lbs., and is provided with an extended bed plate for receiving the dynamo which is coupled direct to the engine, and gives, when running at 250 revolutions per minute, current for 100 16-C.P. lamps at an E.M.F. of 135 volts, this particular E.M.F. being provided to allow of charging accumulators. The number of lamps installed throughout the yacht will be about 100, the fittings being of an elaborate description, and designed specially for this installation. The whole of the arrangements are not yet completed, but in all probability there will be provided a set of accumulators, a projector, and also a powerful submarine arc lamp for carrying on scientific observations at night.

The National Telephone Electrical Society.—This society is still progressing. A short time ago Mr. A. C. Cotterell, the district manager, described his anti-induction apparatus, lately patented, and Mr. Wicker, from Sheffield, gave a short lecture on "The Action of the Transmitter and Receiver." On Friday, February 27th, Mr. P. Loftus, Chief Construction Engineer, gave a very interesting and instructive lecture on "Construction and Renewal of Telephone Lines," illustrated by diagrams. Mr. Loftus also explained an improvement of his own for leading in subscribers' lines. The lecture was very much enjoyed, and there was a large attendance. Last Friday two papers were read by Messrs. Lloyd and Bailey, on "W. E. Magnetos and their Connections," which led to a very interesting discussion on the different kinds of switch hooks.

Copper.—The price of this metal at the beginning of December last was £56 per ton ; at the end of February it had fallen to £53. For a three months' graphical representation of the fluctuation in prices of various metals, we refer our readers to a series of curves in last week's *Engineering*.

The Old Students' Association.—An ordinary general meeting will be held at Finsbury Technical College on Wednesday, March 25th, 1891, at 8 p.m., when a paper will be read by Albion T. Snell, member, on "Coals, Coal mines, and Coal-mining."

Cantor Lecture.—We have received a letter from Mr. Frazer in reply to that which we published last week from Mr. King. Too late for insertion this week, it will appear in our next issue.

Electric Lighting of Camberwell.—The Board of Trade has written to the Vestry of Camberwell, asking whether, considering that the authorised capital of the Camberwell and Islington Electric Light and Power Supply is only one thousand pounds, they think that company will be in a position to discharge the duties imposed upon it by an order, should such be granted. The vestry having, however, received another letter from the company, pointing out that should it obtain an order it has power to increase its capital to any necessary amount, has by way of answer forwarded a copy of this letter to the Board of Trade.

A Caution.—We beg to refer a correspondent who sends us a letter under this title to our article on the Dover-Paris telephone. We were speaking to one of our colleagues in Paris, so there is no reason to doubt that the *Monarch* has been to sea, that the cable has been laid, and that the Post Office Jubilee joke has not been repeated.

The Electrical Standards Committee.—The committee met last week, when the following members were present:—Mr. Courtenay Boyle, Major Cardew, Mr. Preece, F.R.S., Sir William Thomson, F.R.S., Lord Rayleigh, F.R.S., Dr. John Hopkinson, F.R.S., and Professor Ayrton, F.R.S. Mr. Thomas Parker, chief electrician of the Electric Construction Corporation, Limited, Wolverhampton, and Mr. Hugh Erat Harrison, principal of the Electrical Standardising, Testing, and Training Institution, London, attended and gave evidence.

A Warning to Householders.—The Scotland Yard authorities are cautioning the public against men who, calling on the pretence of examining telephone wires, steal any property within reach.

Electrical Trades Section.—A meeting of the committee will be held at Botolph House to-day at 1.30 p.m., when reports of the sub-committees on—(1) Overhead Wires, (2) Telephone Clauses, (3) Board of Trade Form of Accounts, will be submitted. The desirability of co-operation between the telephone and electric light companies for the purpose of placing wires underground in future will be discussed. N.B.—By a special resolution members of the section are admitted to the committee meetings with power to speak but not to vote.

Lecture on the Telephone.—A lecture, under the auspices of the Excelsior Literary Association, was delivered on Monday night, in the Lecture Hall of Trinity Church, Dublin, by Mr. W. Fereday Bottomley, the subject being the telephone. There was a very large attendance.

Electric Light at Exeter.—The Town Council has drawn up a list of terms to be submitted to the company which is applying for a provisional order to light their city. If the terms they propose are accepted, the council will apply for the order, but will lease the undertaking to the company, retaining to themselves the right to determine the lease and take possession at the end of 21, 28, or 35 years, or to let the company retain possession for the full period of 42 years.

International Electrical Exhibition at Toulouse.—An international electrical exhibition will be held at Toulouse during the present year. The exhibition will be open for a period of four months, from May 15th to September 15th next, and will comprise the following sections:—Electricity and Electric Lighting, Electricity as applied to Engineering, Industrial and Commercial Chemistry, Hygiene. Full particulars may be had by applying to the secretary of the Exhibition at Toulouse.

The Launch of the "Electric."—Mr. Sargeant, on behalf of Messrs. Woodhouse and Rawson, informs us that we are in error in stating that Epstein accumulators are used. We can only say that the information was given by Mr. Rawson at the time of the launch, other journals publishing the same statements, therefore the responsibility for the mistake does not rest with us.

Gazette Notice.—The Cadogan Electric Light Company, Limited, is to be voluntarily wound up. Its business will probably be transferred to the New Cadogan and Belgrave Electric Supply.

The Wreck of the "Utopia."—The correspondent of the *Times* says that after the *Utopia* had struck the ram of the *Anson* the search lights of the fleet were thrown upon the scene and rendered most important service in enabling many to be saved who would otherwise have been drowned in the darkness.

Weights and Measures.—Signor Bartlett-Amati, of the National Bank of Italy, has produced and published a very complete list of tables, in which English weights, measures, and money are rendered into their foreign equivalents and *vice versâ*. The book should be useful to merchants and others travelling or doing business in other lands.

Gas Explosions—A Warning.—At the time of the establishment of the first electrical canalisations in Paris, the dangers attendant upon the proximity of gas pipes and electrical conductors were pointed out, and the explosion that took place the other week at the Larne Restaurant, Place de la Madeleine, justifies the apprehensions then expressed. The restaurant is lighted by electricity, receiving the current from an underground conductor connected with the main system of the street, which conductor crosses a gas-pipe supplying a kiosk. The lead of this pipe having become worn through, or corroded, or pierced, the gas escaped freely, and penetrated into the cellar of the restaurant where an explosive mixture was formed, with the result stated. There is no doubt that by establishing gas-pipes and electrical conductors side by side, every facility is afforded for accidents of this nature, and this instance should serve as a warning in the future. No doubt the proper precautions will suggest themselves to those who are qualified by their experience or official position to lay down rules for the prevention of such accidents in the future.

An Electrical Tramway at Lyons.—The municipal Council of Lyons has granted to the Tramways and Railway Company of Lyons an electrical traction tramway line, extending from the station of Dombes to that of Perrache. The following extracts are from the conditions officially laid down by the Council, which will be added to the specification drawn up in accordance with the Act of June 11th, 1880:—1. Mechanical traction by electricity, with self-contained cars. 2. Dimensions of the cars—length, 8 metres; width, 1·8 metres. 3. Cars to start every six minutes; a minimum of 15 stopping places to be established at fixed points. 4. The fare to be—1st class, 20 centimes; 2nd class, 10 centimes. Transfer tickets to any of the company's lines to be obtained for an additional payment of 5 centimes for both classes. 5. Yearly commission to be paid by the company—500 francs per car; 45 centimes per square metre of road granted to the company; 500 francs per car to be paid for the existing service on the lines of Bron and Montplaisir. 6. The company to keep in good condition the line of rails, the spaces between the rails and the side-ways, and to be responsible for all repairs and changes in the existing pavements, and for wood paving. . . . . 9. The company to complete the construction of the said line within a period of six months from the date of the final concession, after the enquiries and approval of the competent authorities. 10. Under no circumstances are the company to require a day's work of more than 12 hours from their servants.

Cox and Company.—This firm of manufacturing electricians have started a new department at their premises at 11, Fetter Lane. For the convenience of students, amateurs, electricians, and others, they have both for sale and for special reference most of the scientific periodicals and publications on the day of issue. Books on scientific subjects, whether in stock or not, they undertake to supply at a discount of 10 per cent. Their establishment being in the midst of the publishing district, and near the Birkbeck and other scientific Institutes, we have no doubt Messrs. Cox and Co. will have many appreciative callers.

Personal.—Mr. Alfred Apps publishes a notice that he has ceased connection with the Saunderson Patents for Electric Arc Lights.

Messrs. Hofler & Co. have been appointed London representatives of Munro's Electrical Manufacturing Company.

Mr. E. Kenealy has been appointed agent for Woodhouse and Rawson United in the West of England, his office being at 7, Bedford Circus, Exeter.

Messrs. Appleton, Burbey and Williamson have taken into partnership Mr. E. L. Joseph.

Electrical Measurements Extraordinary.—A well known electrician, whose special forte is submarine cables, writes to us as follows:—"Can't you stop the New York *Electrical Engineer* committing itself in Herbert Laws Webb's papers on practical testing? *Vide*, for instance, the extraordinary results of testing capacity from both ends simultaneously on page 195 of February 18th."

The Electric Light at Portsmouth.—At last meeting of the Council, the Electric Lighting Committee reported that they had consulted Mr. John Shoolbred, C.E., who had gone over the area proposed to be lighted, and recommended the adoption of the low-tension system now at work at Bradford, and which he is also carrying out for the Brighton Corporation. A committee who had visited Bradford found that the demand for electrical energy had increased to such an extent that it had been necessary to lay down another engine and dynamo. The price charged by the Bradford Corporation is 6d. per Board of Trade unit. The revenue at this rate was now sufficient to cover the working expenses, the interest on the capital, and leave a margin for depreciation of plant. The committee recommended that the electric lighting of the borough be carried out by the corporation, and Mr. Shoolbred engaged to prepare plans and specifications. After a discussion, it was agreed that a report from Mr. Shoolbred should be submitted to the council before proceeding with the work.

Telephone Patents.—A correspondent writes:—"I have been to a sale and have bought a pair of telephones (Silvanus Thompson's patents) bearing the name plate of the New Telephone Company. Must I pay a royalty before I can use them, or shall I be free to use them after July next, when the United Telephone Company's patent expires; or shall I, as a broker, be liable to the United Telephone Company for damages if I offer them for sale? I am told that I am free to use or to sell them under the conditions of settlement of the law suit." Our correspondent has been misinformed; he cannot use them until the end of July.

Overhead Electric Light Wires.—We have received from the London Chamber of Commerce the memorandum and *précis* of correspondence between the Board of Trade, Messrs. Crompton & Co., the Brush Company, several private firms of contractors, and the Electrical Section of the London Chamber of Commerce on the subject of the Board of Trade Rules for overhead wires. We shall probably refer to this matter more fully in our next issue, for the autocratic behaviour of the technical adviser to the board is a fitting subject for comment, considering that his experience is not a very extensive one, and that what little knowledge he possesses on the subject has been gained from the very men whose protests are now ignored.

NEW COMPANY REGISTERED.

J. Cawthra & Company, Limited.—Capital, £120,000 divided into 6,000 6 per cent. preference, and 6,000 ordinary shares of £10 each. Objects: To acquire the business of Italian Cloth Manufacturers, &c., carried on by J. Cawthra and Co., at Dudley Hill and Bradford; to adopt an agreement for that purpose. To generate electricity and apply the same for purposes of lighting and as a motive power, and to supply electric light for the lighting of shops, houses, &c., to manufacture and supply gas and for other purposes. Signatories (with 1 share each), J. Cawthra, Heysham Towers, Lancashire; E. Dracup, Dudley Hill, Bradford; J. H. Ramsden, Manningham, Bradford; W. Sabine, Streatham; F. Bathy, Milton Terrace, Old Trafford, Manchester; W. H. Suddards, 3, Edmund Street, Bradford; S. Laycock, Girlington, Bradford. The number of directors is not to be less than four nor more than seven, the first being the first five subscribers. Qualification, £250. Remuneration to be determined at the general meeting. Registered on the 11th inst. by Wade, Billborough, Booth & Co., solicitors, Bradford.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Foreign and Colonial Electrical Power Storage Company Limited.—The annual return of this company, made up to the 4th inst, was filed on the 11th inst. The nominal capital is £100,500, divided into 100 founders and 20,000 ordinary shares of £5 each. 70 founders and 18,537 ordinary shares are taken up; upon all of the founders' shares the full amount has been called and upon 3,537 ordinary shares £2 per share has been called. The calls paid amount to £4,349, considered as paid to £75,000 and unpaid to £3,075. Offices, 4, Great Winchester Street, E.C.

Ipswich Electricity Supply Company, Limited.—The statutory return of this company, made up to the 7th November last, was filed on the 12th inst. The nominal capital is £100 in £1 shares. 7 shares are taken up, upon all of which nothing has been called. Offices, 112, Belvedere Road, S.E.

Newcastle and District Electric Lighting Company, Limited.—The annual return, made up to the 4th inst., was filed on the 10th inst. The nominal capital is £50,000 in £10 shares. 2,000 shares are taken up, upon all of which £10 per share has been called. The calls paid amount to £19,780 and unpaid to £220. Offices, 38, Grainger Street West, Newcastle-upon-Tyne.

CITY NOTES.

London Electric Supply Corporation, Limited.

THE fourth ordinary general meeting of the London Electric Supply Corporation, Limited, was held on Friday last, at the Cannon Street Hotel, E.C., under the presidency of Mr. James Staats Forbes (the chairman of the company).

The SECRETARY (Mr. Charles B. Waller) read the notice convening the meeting. The report and accounts, published in our last issue, were taken as read.

The CHAIRMAN said he would begin by taking the shareholders through the accounts, in order that the figures might reveal themselves up to date. Those accounts, as they knew, were rendered in accordance with the form prepared by the Board of Trade, and were very comprehensive. They did as they were intended to do; they carried forward from year to year the state of the capital and expenditure in a great many subdivisions. He had occasion at the last meeting to deal at some length with the position of the company at that moment, and what he said that day he proposed to make in continuation of that speech. From the capital account they would see that the whole of the share capital paid up—that was to say, the whole of the authorised—was £555,000. The preference capital last year stood at £100,000, and during the year a portion had been paid up. It would be remembered that they were in some difficulty as to how to deal with the preference shareholders, because, under the arrangement of the prospectus, the calls were to be made at a particular time. He explained at the meeting a year ago that they were not in pressing need of money, and that they thought the circumstances of the time were such as to make it not very desirable that they should call up people's money when interest was at a very high rate. They themselves would be the losers of between what they would probably have to pay and what this company could give them on that deposit; but in order that there should be no ground of complaint, they offered the preference shareholders the option of paying in advance, and that option had been availed of to the extent of £53,000. That was the only change appearing in that account. It would be seen they had now £153,043 of that capital paid up, and £96,957 remained in hand. That was not the end of their available assets at the present moment, for, of course, if that fund were exhausted, they would have the £89,000 unissued shares to fall back upon. No. 2 account did not require any observation, because they had not raised any money on loans; they were all shareholders. Coming to the expenditure, they saw what had been done with the money. That account was very clear. Up to the end of last year they had expended £504,954, and they would

see in the fourteen different items set forth how the money had gone. During the past year the expenditure had very largely increased. No less than £143,501 had been spent, and if they cast their eyes into the total column, and looked at the balance, they would find it was £59,566, so they were getting monstrously near the end of their tether as regarded capital powers. Of course, they would want to know what that money had been spent upon. They could find it all by looking at the different headings—buildings, general construction at Deptford, plant and machinery, mains, purchase of the business—which, with some old legal expenses, stood at £250,397—other mains, including cost of laying from Grosvenor station, electric meters, transformers, and so forth. That indicated, of course, that during the year there must have been a very considerable advance in the provision of machinery for lighting, at all events. They had spent in preparation—in progress, he hoped—towards the completion of what might be called the first stage of their existence, £143,501 during the year. Then the revenue account was also very explicit; on one side they had the cost, on the other the proceeds, and, he was sorry to say, the proceeds just about balanced the cost, which, at the first blush, did not appear very satisfactory; but the board had foresight enough last year to point out, through his mouth, that they must not consider themselves by any means out of the wood. They had, for good or evil, launched themselves on a new path. Mr. Ferranti's system, as everybody knew, was different to the accepted system under which most other companies were at present working, and, therefore, it was in the nature of an experiment—a very costly experiment if it should fail, probably a very profitable one if it succeeded. That time last year, although they were lighting up, they were not doing so with their permanent system, but with a temporary machinery and system which had grown from small beginnings at the Grosvenor, and they had before them the necessity of turning out of the Grosvenor during the year, and transforming the whole of their business at the same time as they were going. He need hardly say that was a very difficult thing to do. That necessity for turning out was probably somewhat in the nature of a curse, because, owing to the state of things, the fire took place at the Grosvenor, which put a sudden stop to their business. He said a curse, but it would probably turn out to be a blessing, because, although they lost a good many customers, and although, no doubt, during the time of the interregnum they lost a good deal of money in the nature of revenue, still it had enabled them to complete their system much more rapidly than they could have done if the business had been running. They would see what the expenses were. Of course, prophesying was a dangerous thing, because, if it turned out well then it was well, as a matter of course, but if it should turn out to be ill, then blame was generally lavished pretty freely; therefore, old birds like himself were very cautious as to what they prophesied. At the same time, they ought to know that the board considered the costs represented by the accounts not by any means normal in their character. They had not, up to this time, had the advantage which they anticipated and were pretty positive they would have when the permanent system was running at Deptford. During the greater part of the time they had the Grosvenor they had to keep up a large expenditure at Deptford, because the very complicated and novel machinery had to be learnt. The fact was, all that business had to be learnt. They had had to find out as they went along, and their misfortunes had arisen from the operation of the very natural law that one could not find out everything at once. Still, they had found out a few things, as he would show them presently. The object of that observation was to impress on them that the large expenditure they saw in the accounts was not normal, but quite abnormal. During a part of the year they transmitted a portion of the supply from Deptford to the Grosvenor; the Grosvenor supplied one portion of the current, and Deptford the other. That was in order to test the possibility of doing what a good many people believed could not be done; it was thought that the idea of transmitting electricity so great a distance must fail. But, then, it had not failed. Mr. Ferranti's anticipations had been entirely confirmed by the result. They had had a great number of mains laid on Mr. Ferranti's principle of concentric mains. The great trunk conducts were run from Deptford to London, to be there distributed through the minor conduct or smaller main to the consumer. Well, they had to be tested, and testing them was an expensive thing. Then, again, they had to clear out of the Grosvenor—to take out the engines, dynamos, and the whole of the machinery, and remove a great deal to Deptford. All that caused a continual expense and a continual interruption to business, and he for one was surprised that the accounts had come out as well as they had, because, in addition to the difficulties and large expenditure they incurred in working under the conditions of the moment, came the fire, when, as they knew, the converters were all destroyed, and without the converters they could not light. Well, they improved the opportunity. They were nearly staggered by the fire at the moment, but made up their minds that then was the time to postpone for a term any attempt to light, trusting to the forbearance of their customers, which he must say, in passing, they had received without stint. And now they had lit up—on a modest scale at present; but still it had been enough to test one or two important things. For two or three weeks the parts of London they supplied had been lit from Deptford exclusively, and the mains had acted well. Recently, at all events, he was given to understand there had been no complaint about the light. When the fire took place they were lighting probably 26,000 lights; now they had got back to 10,000, and they would not be wanting in customers as their capacity to increase the supply increased day by day and week by week. In the face of these difficulties they would see what they had taken. They managed to get by the sale of current per meter £16,280, and by sale under contracts £9,700. This was nearly identically the total of last year, but it was quite different in division. Last year the great bulk of the supply was done by contract, and much the smaller part by meter; now they had done much more by meter, which meant that in the interval they had also found a reliable meter. He supposed most of their customers preferred to pay by a reliable standard to the uncertain footing of a contract. He had no doubt that the contracts, particularly in the preceding year, had been very bad for them, but they had had no experience until this year upon which to found lighting by contract. On November 15th the fire took place, and from then until the end of December they had a large expenditure but no income. He hoped that with that explanation, and some further explanation which he might have to give them when he came to Mr. Ferranti's report, they would consider that, after all, their position was not so bad as it might have been. The time was approaching when the capital part of the business neared its completion. Of course, they could not initiate a business of this kind, enter upon large building operations like those at Deptford, and put in thousands of pounds' worth of machinery, without an enormous amount of trouble, difficulty of contracts, and otherwise, and while that class of work was in progress it was both usual and reasonable that the bulk of the charge should fall upon construction; but the moment they were finished they came upon the footing of an ordinary commercial undertaking, and the expenditure must go to revenue. What they had done this year, as they were approaching the end of the first stage of their construction, was to enhance considerably the apportionment to revenue of the general charges. That item in itself would account for about £1,500, which they had added, as compared with the preceding year. The amount carried to the management expenses in the preceding year was £2,500; this year, in round numbers, it was £3,900, and he supposed, when the thing ran purely and entirely as a going concern, the whole of that would go against the revenue. Then they had made a rather larger reserve against bad and doubtful debts and other items. They had a good many accounts outstanding when the fire occurred, and, of course, people were very sore; but, by explanation and persuasion, and a little pleading, they took a very reasonable view, and it was very gratifying to the company to know that the great bulk of their accounts had been paid up in full. There were cases where they had found it expedient to make some slight concessions—cases of peculiar hardship—and they had thought it better, as all those were not settled, to place somewhat more to reserve. Then they thought that as the fire was a calamity, they had better get it out of their minds at once and charge it to revenue. The cost was only about £1,183. Of course the chief loss really was the stoppage of their business; that was a serious affair, but, as he had said, they thought it was compensated for by the benefit of the opportunities it afforded them of proceeding with their business in a more prompt and efficient fashion than it would have been possible if they had had to light and construct at the same moment. They carried forward a balance of £813; last year the balance was £920. That was the result of all their patience, responsibility, ability, &c., of the past year. If that were the state of things under which they were going to continue, it would be sufficiently discouraging, but he did not think it was. He thought there was every indication that during the present year things would assume a totally different aspect. The reserve fund account was a merely formal account in which the item was brought down from net revenue, and then there was the balance sheet. He did not propose to go further into those unless it were in the nature of answers to questions. He observed one or two of their critics present, and probably they would ask some questions, which he would answer to the best of his ability. It was usual for a chairman to begin by reference to the directors' report, but the fact was that in this company the directors played a comparatively secondary part. At the present moment the important factor was the engineer, and, to use a technical phrase, they had had to bring him to earth last year. They made him report, and they adopted his report, because they believed in its general accuracy; but they had thought it better to make him report again, and they adopted it again, also because they believed in its general accuracy. He daresay the proprietary had taken the trouble to read it, but it was the old story. To epitomise it, it came to this—during the year the large expenditure seems to have been justified by the results. The concentric mains, which were an idea a year ago, were now a fact. A good many clever people thought they would not work. They did work. A great many clever people thought they could not possibly work without great detriment to the Postmaster-General and the telephone companies. They did work without detriment to either; and in order that this system might be not only the most economical system when it was in full operation, but also beyond question the safest system, the Board of Trade had already consented to—as far as they were concerned—suspend one of the stringent conditions of the original order under which the different lighting companies were brought into creation. They were under no circumstances whatever to earth the current. The theory was that if they did, the Postmaster-General, the telegraph companies, and the railway companies could not carry on their business, and there did appear for a time some fear that that was so; however, the moment the concentric mains under the earth were made the channel for conveying the current that difficulty vanished. Then they found that earthing could be done, and that it would make this the safest company. This system of earthing—which, after a great deal of difficulty, and only by bringing in the aid of those great authorities on electricity, Sir William Thomson and Dr. Fleming, they persuaded the Board of Trade to grant this immense concession—had the entire concurrence of the Post Office. Being allowed to earth, all danger of fire was absolutely removed; of course, when he said absolutely removed, he spoke relatively, but it was almost that. At any rate, those dangers which the timid apprehended had been enormously modified, and he supposed that under that system the electric lighting of houses was infinitely safer than gas, and vastly safer than either oil or candles. Then there was another thing. This 10,000 volts, which was to be the normal pressure of their permanent work, was thought to be one of the impossibilities. There were two things about it: some thought they could not do it at all, and others thought it could only be done with such an enor-

mous waste in transmission as to nullify altogether the economy in production. Now, they had tested that, and that prognostication had been contradicted. The loss of current from the dynamo entering the transformer at the transforming station was practically *nil*. In their case, as in the case of all other companies, there was necessarily a quantity of current lost in getting it from the transformer to the house of the customer; but between Deptford and the transformer there was practically no loss—it was quite insignificant. The idea of 10,000 volts had made people's hair stand on end. Mr. Edison's stood on end when he told him. (Laughter.) He expressed some doubt, first of all, as to whether it could be done, and, secondly, as to whether the waste would not be very great. It was said that Mr. Edison could not be taught anything, but they had taught him that. He had taught the world a great deal, and it was satisfactory to be able to help him in return. (Laughter.) Now, he would be able to turn Niagara to account, because they must have high tension for that; with low tension they certainly could not do that business. In order to give them some idea of the capacity and efficiency of those mains, he might mention that they had really been tested up to 17,000 volts. One paragraph in Mr. Ferranti's report everyone ought to study and think of a little. If the light went out or something went wrong with it, people immediately ejaculated something about the evil deeds of the company, but, as Mr. Ferranti said, "the work of laying was of necessity performed by unskilled labourers, who had neither experience nor training in such work." That was the whole story. Not only the labourers in that matter were unskilled, but they all were. There was no skilled labour for this business. It had got to be acquired, and people who would take the trouble to consider that a moment would, he was sure, find some apologies in their hearts for those who had had to make everything by stages, and find out the means by stages. They had got dynamos working up to 30,000 lights. Dynamos of greater capacity were in course of construction, and when they were ready they would send up a current to the extent of 60,000, so that they had got completed and paid for a capacity of 90,000 lights. They would not think of using that power to the full capacity, because under the Board of Trade regulations—and if they had not made the stipulation, they would have made it for themselves—they could not do so. They would not work up to their full capacity, but have a reasonable reserve. Mr. Ferranti said in his report: "With these two large machines supplying your circuits, the first important stage of your undertaking will be completed"—that was to say, with the 90,000 lights they would have practically done all the work. It might as well go forth to the world from him that the consumers themselves would be chiefly to blame if fire formed an element of serious consideration in electric lighting, because, with installation conducted with care and in accordance with plans which were now thoroughly understood and adopted by the insurance companies, fire was next to impossible. Now they came to the second stage. Shareholders would see their money was running short. With companies it was the same as with a man. If he started young, with a full purse, he would never be easy till he came to the bottom of it. (Laughter.) That was their condition; but they were now going to be mighty prudent; that was to say, before entering into the next stage of their operations—the stage that would develop 200,000 more lights—they would want some more money, and they would not get it, and he should not have any hand in trying to get it, until they had established the company as a profitable commercial undertaking. If they attempted to raise money before then they could only do so on disastrous terms. Their 60,000 lights—which meant something more, perhaps, than £60,000 of income—would secure them from any difficulty in going into the more heroic thing. He was much too old to be caught prophesying, but some sanguine man—their secretary, for instance, who was very sanguine—would say that they would be having that £60,000 by that time next year. That might be the case; if it were, he thought the position would be so much improved that there would be no difficulty about money for further prudent progress. He did not know any man who during the last year had had more responsibility on his back than Mr. Ferranti. He had pledged his reputation and his fortune in the matter, and had laboured day and night to achieve the result he had promised the directors. He had achieved it, and he had done so much in redeeming what a year ago seemed a most difficult position as entirely to justify his present opinion, which was expressed in this paragraph:—"I desire to call attention to the fact that from the commencement of your operations to the present time no engineering or electrical difficulties whatever have arisen which I have not been able to overcome, and at the present moment I know of no weak point in your system, and consider success to be now assured." He would not have been so unless he had been absolutely convinced of its truth, nor would the directors allow it to appear in his report unless they had felt quite sure they could believe it themselves. With regard to the "bogey" of overhead wires, there was really nothing in it; but everyone thought he was going to be killed by them, and therefore companies in London had been put under obligation to remove them by August next. This company was carrying out a system of underground mains, and no doubt they would have it done long before August, and thus conform to the law. Mr. Ferranti, in his last paragraph, said:—"The great advantage of the high-pressure system is apparent in that the loss involved in transmission of current from Deptford to the distributing stations is inappreciable, while the facilities for procuring coal and water there, sufficiency of room for machinery and appliances, and freedom from the legal and financial consequences attending the erection of generating stations in crowded neighbourhoods, cannot fail to tell their own tale in the working expenses of the current year." This just showed what a young man Mr. Ferranti was. (Laughter) He had said something very encouraging to the shareholders, but had put himself under the serious obligation of cutting down the working expenses during the year. He thought, however, they had really weathered the storm, and, after overcoming great difficulties, saw daylight, and that was the opinion of all his colleagues. Their engineers—and they had got not only Mr. Ferranti (in whom they had the greatest confidence) but also Dr. Fleming, an electrician of great eminence—were quite at one on that point. They believed they had now entered on a stage which would lead to prosperity—at all events, they hoped so. In conclusion the chairman expressed warm thanks to the Board of Trade for the enormous amount of forbearance and consideration they had shown the directors. From the highest official to the lowest they had done everything they could to afford the company an opportunity of establishing its principle, and they deserved the company's best thanks. He then moved that the report and accounts be adopted.

Lord WANTAGE seconded the motion, which, after a few words from Mr. G. Horsfield and Mr. Adams, was carried unanimously.

The retiring directors—Mr. Francis Ince, Mr. Joseph Pyke and Mr. Arthur F. Wade—were re-elected, as were also the auditors, Messrs. Kemp, Ford & Co.

Mr. CROUCH proposed and Mr. ADAMS seconded a hearty vote of thanks to the chairman and directors, which was unanimously passed.

The CHAIRMAN having briefly replied, the proceedings ended.

The Direct Spanish Telegraph Company, Limited.

ON Tuesday last this company held its thirty-fifth ordinary general meeting at Winchester House, Sir James Anderson, the chairman of the company, presiding.

The SECRETARY read the notice convening the meeting, as also the minutes of the three last previous ones. These were approved and signed.

The CHAIRMAN said: They would see from the report (published in our last issue) that they had earned £1,612 more in the last half year than in the corresponding half of last year, and to do this had carried 138,000 more words at an increased cost of £221. The telegrams remained steadily at an average of from 10½ to 10¾ words, and had done so for the past two or three years, evidence that the science of codifying had reached a point beyond which it could not be carried at any rate for some years to come. They had established a duplex communication between London and Bilbao, and the time occupied in transmitting telegrams from London there was only three minutes, and to Madrid only thirty minutes.

The SECRETARY here read a letter from the Director-General of Telegrams in Madrid congratulating the company upon this fact.

The CHAIRMAN resumed: He thought that was very satisfactory. To be able to telegraph to Madrid in half an hour and to Bilbao in three minutes was as far as they cared to go. Whatever posterity might do the present generation was satisfied. They would see from the report that the reserve fund amounted to £23,000. Nearly the whole of this money was invested and bearing interest which also went to increase reserve. They had expended upon duplexing the London-Bilbao cable £886 and wiped off £431, the balance of the cost of removing the new London station from Gracechurch Street, and £43 for removing the station at Bilbao altogether. Altogether £1,300, all out of revenue, and they carried forward £566 after paying the ordinary shareholders 7 per cent. This was a better result than he expected when he last addressed them, but they had yet to see the result of the reduction of a half-penny in the tariff. Losses had been caused by the bad crops in Spain and the recent strikes in London, which had affected the shipment of iron-ore at Bilbao, as also by the recent unprecedented snowstorm which had interrupted all traffic south of Exeter. They were very much indebted to the Post Office for the assistance rendered. They had assisted them in every way; but the storm was so overwhelming that he was thankful they had escaped without losing lives. He had received that morning a letter from the Lands End from which it appeared that they had had such a time down there as he had never heard of before; but he was glad to say the staff had heroically done their duty and he personally felt extremely indebted to them because he was always anxious to have the service kept up. Traffic had, however, been very much interrupted, so much so that in telegraphing to the Lands End they had found their quickest way was by Marseilles and Gibraltar. Now that communication was restored again he doubted not they would get back all their traffic. He did not take a pessimistic view of the future but they might not always be able to give 7 per cent., so 1 per cent. had been called bonus, which meant that they did not consider this one per cent. an assured dividend which they could properly divide and promise to divide continuously. They would all hope, however, that it might be really continued; but even if their tariff increased they ought not to divide any more revenue than 7 per cent. every shilling beyond which should be laid by. They had only one cable; true they had a joint purse with the Eastern Telegraph which went a long way to save them, but he did not consider any telegraph company a success till the system was duplicated. An enterprise of this kind, telegraph or railway, should have a large margin of carrying capacity, and a large margin of security. Without these they could not say they were in a good position. He looked forward to a time when increased revenue would justify the duplicating of the whole system, he therefore wanted them to accumulate all the money they could, and 7 per cent. was a large enough dividend. The board looked forward to paying off half the debentures in 1894, and issuing the other half at 4 per cent. if there were no disastrous breaks in the cable. He had heard that there was a sore feeling on the part of preference shareholders, when they saw the ordinary shareholders getting 7 per cent. and themselves only 10, but he would do what he could to show them what would have been the position of the proprietors had they not reduced their capital. When the board was reconstituted they were not receiving any dividend. The dividend upon preference shares was three years in arrear. They had totally lost the main cable, and had raised £62,000 in debentures to keep the

Company's stations and property from being utterly lost. They had to go to court to get the question decided whether they could reduce preference capital as well as ordinary. They had had their doubts about this, and had desired to give the preference shareholders a larger proportion than they had obtained, but the court on appeal had said decidedly no, but assuming they had not reduced the capital, they could not by law have paid any dividend whatever until their lost assets were restored, and even had their revenue shown the elasticity which it had recently done, they could not have paid the preference shares any dividend for about ten years. By the reduction of capital they were placed in a position to pay the preference shares the whole of the three years' arrears at once, and a continuous dividend of 10 per cent. upon the reduced capital ever since. The shares were now at £10 in the market, before the reduction of capital they were hardly saleable at £7. They had acted altogether in the shareholders' best interest when they decided to know the worst—to examine the cable and face the position. All their revenue would not have maintained that old cable. Now they had a reserve of £23,000 and a contingency fund of £2,000. They had a growing revenue, and were justified in looking forward to the reduction of their debenture debt at a comparatively early period, and at a price which their improved credit would entitle them to ask for, either in the open market or from shareholders. Looking back on the whole thing, they could not have done better in any way. He concluded by moving the adoption of the report.

Mr. EDMUND ETLINGER seconded.

In reply to questions put by Mr. Jackson, the chairman said that he would not undertake to fix even the minimum amount that he would consider necessary for a reserve fund, and that a single cable would cost about £180 a knot, say £180,000, for one from London to Bilbao, and about half as much for one from Marseilles to Barcelona.

Mr. COCHRAN thought the board were putting too much to reserve. When the re-construction of the company was proposed, the chairman had insisted he would have nothing to do with it unless he were allowed to lay by £5,000 a year as reserve fund, but the board were laying by £7,000. Surely, £5,000 was enough to provide against the contingencies which might overtake them, and the board might well consider whether, should the present available margin continue at their disposal, they should not give a little more to the shareholders.

The CHAIRMAN replied, insisting on the necessity of a substantial reserve fund. They would get cables cheaper if they paid cash for them than if they issued debentures. They could not be in the right position without a large margin of carrying capacity, and to get that they wanted money.

The report and accounts were unanimously adopted. Sir James Anderson and Mr. Edmund Etlinger who were retiring by rotation from the board of directors were re-elected. Mr. Herbert R. Duke was re-appointed auditor of the company's books and accounts, and the usual vote of thanks brought the meeting to a close.

South of England Telephone Company.

AN extraordinary general meeting of the above company was held on Monday last at Winchester House, to consider a proposal, published last week, to sell the Company's property to the National Telephone Company. Mr. D. O. Bateson, the chairman of the Company presiding. The terms of the proposed sale were that the National Telephone Company was to take over the business of the Company from the 1st November, 1890, the profits of the six months prior belonging to the shareholders of the South of England Company; and the purchase consideration consisting mainly of 12,000 fully paid ordinary shares of the National Company, and £70,000 worth of their 4½ per cent. debenture stock.

The CHAIRMAN read the three resolutions that were to be submitted to the meeting. The first approving of the amalgamation of the South of England with the National Telephone Company, and the other two directing the voluntary winding up of the Company. Mr. Thomas Abercrombie Welton was to be appointed liquidator.

Mr. BILLETT formally moved the first resolution. He said that shareholders might complain of the terms of the amalgamation, but better security meant less dividend, and certainly the security of a company which had paid 9 per cent. was a much better security than the South of England offered. The directors had hoped to get slightly better terms, but the revenues were small, and there were many risks which had made this impossible. They were nearing the end of their capital, and if they borrowed money, unless their revenues correspondingly increased, their shares would suffer. Then if the Company was to go on they must have a large reserve fund or else decrease their dividends by putting down to revenue expenses which were now paid out of capital. The National Company had said during negociations, that they did not see how they were going to get anything out of the transaction, for everything had been done so cheaply that there was nothing left to save; but they had a comparatively poor district, and would not expect without a large expenditure of capital that their dividend would go on increasing. They had paid ½ per cent. last year, and 1 per cent. the year before, and might perhaps pay 1 per cent. again, but if they were to make the large reserve they ought to make it was doubtful whether they could go beyond that. Instead of that they got a share in the National, and though it might be said that they were at a discount yet they had earned 9 per cent. last year and would probably earn as much this year too. The arrangement gave the South of England shareholders a marketable share, the benefit of the National Company's reserve fund and the prospect some day of an increased dividend. All these considerations had been weighed by the directors and though the terms were not so good as they would have liked yet they were sufficiently favourable to be submitted to the shareholders. The action of directors in a case of this sort was always open to question; but his own feeling was that the terms were favourable and that they were acting right by the shareholders in this matter, and though the National Telephone Company lost nothing by the transaction yet the South of England shareholders certainly did not by changing their shares for the shares and debenture stock of the National Telephone Company.

Mr. MACGREGOR seconded. The advantages of amalgamation had been pointed out to them as also the difficulties which lay before them as an isolated company. The dangers ahead were very real though perhaps not immediately apparent. Throughout the negotiations the directors had had but one object in view the interest of the shareholders. They had endeavoured to make the best bargain they could and had made a fair one. He was himself the largest shareholder in the company.

A good deal of opposition was offered to the passing of the resolution.

Mr. PAWLE thought it one of the most extraordinary he had ever heard proposed. The directors had said nothing till then about the reserve fund which they now declared it necessary they should have, and when they had paid only ½ per cent. last year they had led the shareholders to believe that the smallness of the dividend was owing to snowstorms. The shares of the National Telephone Company were already at a discount and those who wanted them could buy them in the market. Their own shares were at any rate worth half-a-crown, but the price proposed was no more than 1s. 9d.

Mr. BILLETT interrupted, to point out that even at the lowest quotation for National shares, they were getting 3s. 9d. per share.

Some altercation arose on this. Eventually Mr. THOMPSON rose to second the rejection of the resolution. To sell their shares to the National Company, even at 3s. 9d. or 4s. was great folly, considering that they were just beginning to turn the corner. The National was getting altogether the best of the bargain, and this was not the right moment to sell, at any rate on the terms proposed.

Mr. FITZGERALD supported the action of the directors. The shareholders had overlooked the danger of competition. Competition in a telephone business was a disastrous thing. He had been in one or two telephone fights and knew what it was to have the rates knocked down and all the profits taken away. A small company like the South of England was in a rather dangerous position, for a very few people could go into one of their towns and knock down their rates, and where would they be then with their capital nearly gone? It was no argument to say the bargain was a bad one. The fact that he had given 7s. 6d. for a share worth only 3s. 9d., was no reason why somebody should give him 8s. for it. Personally, he thought that unless the shareholders passed the resolution they would find themselves in a very bad way in about a year's time.

Other shareholders spoke mostly in favour of amalgamation, but complaining of the badness of the terms on which it was to be made. The chairman then put the resolution to the meeting, and it was carried by 25 to 14. The unanimous agreement to the other two resolutions followed as a matter of course, and a vote of thanks—not a very hearty one—concluded the meeting.

Brighton and Hove Electric Light Company, Limited.

THE fifth annual report of this company, to be presented to the general meeting of the company next week, shows that the profit for last year, after an ample sum for depreciation of plant had been written off, amounts to £768 2s. From this must be deducted £123 6s. 7d. interest on debentures, leaving £644 15s. 5d. net. The balance brought forward from the 1889 account and added to this gives a total of £1,202 15s. 1d. The directors recommend that £232 9s. be written off from "Suspense account, Garman case," £750 be distributed as 5 per cent. dividend, and £220 6s. 1d. be carried forward. The report states that the directors have been again disappointed in their efforts to obtain a provisional order to supply Brighton. If they eventually get it they will withdraw their overhead wires from the corporation area; if not, they will continue to supply the whole of the the town by their overhead wires. The directors have repeatedly tried, but unsuccessfully, to come to terms with the corporation. Ultimately failing to do so, they intend to lay down additional plant. To do this they must obtain some more capital.

The Direct Spanish Telegraph Company, Limited.—This company's office in Gracechurch Street is now again in direct communication with Bilbao and Madrid, and there is now no delay in the transmission of telegrams to Spain.

Eastern Telegraph Company.—The directors announce the payment on the 14th proximo of a quarterly interim dividend of 2s. 6d. per share.

National Telephone Company.—Letters of allotment for the 4½ per cent. debenture stock have been posted.

TRAFFIC RECEIPTS.

The Brazilian Submarine Telegraph Company, Limited. The receipts for the week ending March 13th, 1891, amounted to £5,066.

The City and South London Railway Company. The traffic receipts for the week ended March 14th, amounted to £749.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending March 13th, 1891, after deducting 17 per cent. of the gross receipts payable to the London Platino-Brazilian Company, were £4,063.

The West Coast of America Telegraph Company, Limited. Traffic receipts for the month ending 28th February, 1891, £4,600.

SHARE LIST OF ELECTRICAL COMPANIES.

Present Amount Issued.	Name.	Stock or Share.	Closing Quotation. (Mar. 12)	Closing Quotation. (March 19).	Business done during week ending March 19, 1891. Highest.	Lowest
250,000*l*	African Direct Telegraph, Ltd., 4 p. c., Deb. Regd. and to Bearer	100	99 —102	99 —102	...	...
1,381,380*l*	Anglo-American Telegraph, Limited	Stock	47½— 48⅝	47½— 48⅝	48½	...
2,809,310*l*	Do. do. 6 p. c. Preferred	Stock	84½— 85½	84½— 85½	85½	84⅞
2,809,310*l*	Do. do. Deferred	Stock	11 — 11½	11 — 11½	11⅜	11⅛
130,000	Brazilian Submarine Telegraph, Limited	10	11¾— 12¼	11¾— 12¼	12	11⅞
84,500*l*	Do. do. 5 p. c. Bonds	100	100 —103	100 —103	...	...
75,000*l*	Do. do. 5 p. c., 2nd Series, repayable in June, 1906 ...	100	103 —107	103 —107	...	...
63,416	Brush Electric Engineering Ordinary, Nos. 1 to 63,416	3	1⅞— 2⅛	2⅛— 2⅛	2 7/16	2⅛
63,416	Do. do. Non cum. Preference, Nos. 1 to 63,416	2	1½— 2	1½— 2	1⅞	...
50,000	City and South London Railway, Nos. 1 to 50,000	10	5½— 6½	5½— 6½	5	...
$7,216,000	Commercial Cable, Capital Stock	$100	108 —110	108 —110	109¾	109¼
224,850	Consolidated Telephone Construction and Maintenance, Limited ...	14/-	7/16— 9/16	7/16— 9/16	...	...
20,000	Crompton & Co., Ltd, 7 p. c. Preference Shares, Nos. 1 to 20,000	Stock	5 — 5½	5 — 5½	...	...
16,000	Cuba Telegraph, Limited	10	10½— 11½	10½— 11½	11⅜	10¾
6,000	Do. do. 10 p. c. Preference	10	16½— 17½	16½— 17½	...	...
12,931	Direct Spanish Telegraph, Limited, ... (£4 only paid)	5	3¾— 4¼	3¾— 4¼	4 1/16	...
6,000	Do. do. 10 p. c. Preference	5	9½— 10½	9½— 10½	...	...
60,710	Direct United States Cable, Limited, 1877	20	10⅛— 10⅜	10⅛— 10⅜	10⅜	10¼
400,000	Eastern Telegraph, Limited, Nos. 1 to 400,000	10	14 — 14¼	14⅛— 14⅜	14¼	14⅛
70,000	Do. 6 p. c. Preference	10	15¼— 15½	15¼— 15½	15⅜	...
200,000*l*	Do. 5 p. c. Debs. (1879 issue), repay. August, 1899	100	107 —110	107 —110	...	...
1,200,000*l*	Do. 4 p. c. Mortgage Debenture Stock	Stock	107 —110	107 —110	109	107½
250,000	Eastern Extension, Australasia and China Telegraph, Limited ...	10	14¾— 15¼	14¾— 15	15	14⅝
91,800*l*	Do. 5 p. c. (Aus. Gov. Sub.), Deb., 1900, red. ann. drgs. reg. 1 to 1,049, 3,976 to 4,326	100	103 —106	103 —106	...	...
325,200*l*	Do. do. Bearer Nos. 1050—3,975 and 4,327—6,400 ...	100	103 —106	103 —106	...	...
320,000*l*	Do. 4 p. c. Debenture Stock	Stock	105 —108	104 —107	...	...
145,300*l*	Eastern and South African Telegraph, Ltd., 5 p. c. Mort. Deb. 1900 redeem. ann. drawings, Registered Nos. 1 to 2,343	100	103 —106	103 —106	...	...
198,200*l*	Do. do. do. to bearer, Nos. 2,344 to 5,500	...	103 —106	103 —106	104	...
201,600*l*	Do. do. 4 p. c. Mort. Debs. Nos. 1 to 2016, red. 1909	100	99 —101	99 —101	...	...
45,000	Electric Construction, Limited, Nos. 101 to 45,100	10	5 — 6	5 — 6	...	...
19,900	*Electricity Supply Co. of Spain, Nos. 101 to 20,000	5	4½— 5	4½— 5	...	...
66,750	Elmore's French Patent Copper Depositing Co., Ltd, Nos. 1 to 66,750	2	1⅞— 2	1 — 1½	1⅜	...
70,000	Elmore's Patent Copper Depositing, Limited., Nos. 1 to 70,000 ...	2	2⅞— 3¼	3 — 3½	3¼	2 1/16
67,385	Elmore's Wire Mfg., Ltd., Nos. 1 to 67,385, issued at 1 p.m., all pd.	2	1¼— 1⅜	1 — 1½	...	...
20,000	Fowler-Waring Cables, Nos. 301 to 20,300 ... (£4 only paid)	5	2½— 3½	2½— 3½	...	...
180,227	Globe Telegraph and Trust, Limited	10	9½— 9⅝	9½— 9½	9⅝	9 3/16
180,042	Do. do. 6 p. c. Preference	10	15 — 15½	15 — 15½	15	...
150,000	Great Northern Tel. Company of Copenhagen	10	16¾— 17½	17 — 17½	17¼	17⅛
220,000*l*	Do. do. 5 p. c. Debs. (issue of 1883) ...	100	103 —106	103 —106	...	...
9,384*l*	Greenwood and Batley, Ltd., Ordinary, Nos. 4667 to 14,000 ...	10	10½— 11½	10½— 11½	...	...
5,334*l*	Do. 7 p. c. Cumulative Preference, Nos. 2,667 to 8,000	10	11 — 12	11 — 12	...	...
41,600	India-Rubber, Gutta Percha and Telegraph Works, Limited ...	10	18½— 19½	19 — 20	18¾	19½
200,000*l*	Do. do. 4½ p. c., Deb., 1896	100	104 —106	104 —106	...	...
17,000	Indo-European Telegraph, Limited	25	37 — 39	38 — 40	39⅞	39⅝
11,334	International Okonite, Ltd., Ordinary Nos. 22,667 to 34,000 ...	10	8½— 9½	7 — 8	...	...
11,334	Do. do. Preference Nos. 5,667 to 17,000 ...	10	9½— 9⅝	9½— 9⅝	...	...
38,348	London Platino-Brazilian Telegraph, Limited	10	6½— 7½	6½— 7½	...	...
100,000*l*	Do. do. do. 6 p. c. Debentures	100	105 —108	105—108	...	...
43,900	*Metropolitan Electric Supply, Ltd., Nos. 6,101 to 50,000 (£9 paid)	10	8⅝— 9¼	8⅝— 9¼	9 1/16	...
438,984	National Telephone, Limited, Nos. 1. to 438,984	5	4⅝— 4¾	4⅝— 4⅝	4 11/16	4 3/16
15,000	Do. 6 p. c. Cum., 1st Preference	10	12⅜— 13½	12⅜— 13½	...	...
15,000	Do. 6. p. c. Cum. 2nd Preference (£8 only paid)	10	10½— 10⅝	10 — 10½	10	...
220,000	Oriental Telephone, Ltd., Nos. 80,001 to 300,000 (11s. only paid)	1	¼— ⅜	7/16— 7/16	...	...
9,000	Reuter's Limited	8	8½— 9	8½— 9	8 15/16	...
209,750	South of England Telephone, Limited, Ordinary Nos. 1 to 2,000, 2,501 to 3,500, 93,251 to 300,000	1	⅛— ¼	⅛— ¼	...	...
20,000	Do. 6 p. c. Cum. Pref., Nos. 1 to 20,000 (£3½ only paid)	5	2⅞— 3¼	2⅞— 3¼	...	...
3,381	Submarine Cables Trust	Cert.	115 —120	115 —120	..	...
78,949	Swan United Electric Light, Limited ... ... (£3½ only paid)	5	4½— 5	4½— 5	4⅝	4 9/16
37,350	Telegraph Construction and Maintenance, Limited	12	44 — 46	45 — 47 xd	44½	46½
150,000*l*	Do. do. do. 5 p. c. Bonds, red. 1894	100	102 —105	102 —105	...	...
58,000	United River Plate Telephone, Limited	5	3 — 4	3 — 4	...	...
146,128*l*	Do. do. 5 p. c. Debenture Stock ...	Stock	85 — 95	85 — 95	...	...
3,200*l*	Do. do. 7 p. c. Debs., Nos. 1 to 1,000 ...	100	... ...	... ...	...	...
15,609	West African Telegraph, Limited, Nos. 7,501 to 23,109	10	8 — 9	8 — 9	...	...
290,900*l*	Do. do. do. 5 p. c. Debentures	100	97 —100	97 —100	...	...
30,000	West Coast of America Telegraph, Limited	10	2 — 4	2 — 3	...	...
150,000*l*	Do. do. do. 8 p. c. Debs., repayable 1902 ...	100	94 — 99	92 — 97	...	...
64,174	Western and Brazilian Telegraph, Limited	15	12 — 12½	12 — 12½	12 7/16	12¼
27,873	Do. do. do. 5 p. c. Cum. Preferred	7½	6⅞— 7¼	6⅞— 7¼	6⅞	6⅞
27,873	Do. do. do. 5 p. c. Deferred	7½	5¼— 5⅝	5¼— 5⅝	5⅝	5 9/16
200,000*l*	Do. do. do. 6 p. c. Debentures "A," 1910 ...	100	103 —106	103 —106	106	...
250,000*l*	Do. 6 p. c. Mort. Debs., series "B" of '80, red. Feb., 1910	100	103 —106	103 —106	...	...
88,321	West India and Panama Telegraph, Limited	10	2⅝— 3	2⅝— 3	...	...
34,563	Do. do. do. 6 p. c. 1st Preference ...	10	11½— 12	11½— 12	11⅞	11 1/16
4,669	Do. do. do. 6 p. c. 2nd Preference ...	10	11 — 12	11½— 12½	...	...
$1,336,000	Western Union of U.S. Tel., 7 p. c. 1st Mortgage (Building) Bonds	$1,000	120 —125	120 —125	...	...
175,100*l*	Do. do. 6 p. c. Sterling Bonds	100	100 —104	100—104	...	..
42,853	*Westminster Electric Supply Corporation, Ord., Nos. 101 to 42,953	3	3⅜— 4	3⅜— 4	4	...

* Subject to Founders' Shares.

LATEST PROCURABLE QUOTATIONS OF SECURITIES NOT OFFICIALLY QUOTED.

Blackpool Electric Tramway Company, Limited, £10 (£6½ paid), 7¼—7⅜.—City of London Electric Lighting (Pioneer), Shares of £50, £25 paid, 55—60.—Elmore's Austrian Copper Depositing, 20s., 10s. Dis.—Elmore's Priorities, 3⅜—4¼.—House to House Company (£5 paid), 4⅜—5¼.—London Electric Supply Corporation, Ordinary (£5 paid), 2—2¼.—Manchester Edison and Swan Company, £9 (£1 paid) 2s 6d.—5s.—St. James's and Pall Mall Electric Light £5, 6⅛—6⅜.—Woodhouse & Rawson Ordinary of £5 (£2 10s. paid), 2⅜—2½.—Preference, fully paid 3⅞—4⅛.—Debentures 90—95.—Woods Electric Car, £10 paid, ⅜—1½.

BANK RATE OF DISCOUNT.—3 per cent. (29th January, 1891).

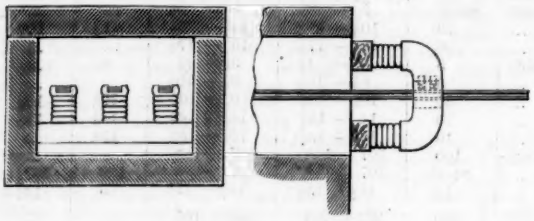
UNDERGROUND CABLES.*

By STUART A. RUSSELL.

(*Concluded from page* 334.)

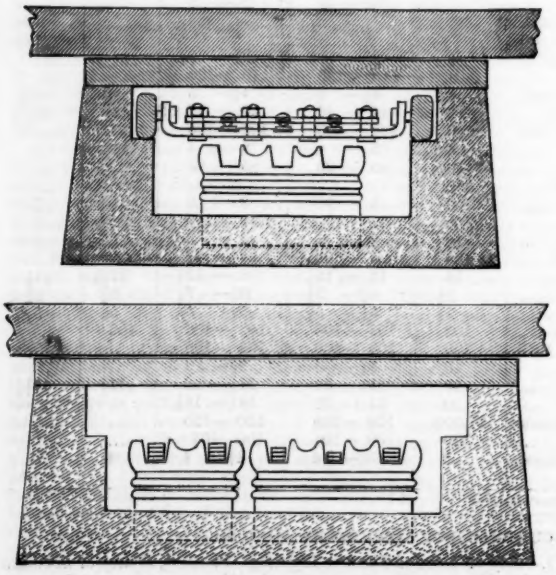
I now propose to describe briefly the systems of mains which have been laid by the supply companies in London, taking first those working on low pressure systems.

The Kensington and Knightsbridge Company's mains consist of bare copper conductors arranged on Crompton's system, in which a cutout of brick or concrete, 15 inches to 20 inches wide and about 12 inches deep, inside measurement, is built under the footway. At intervals of from 10 to 20 yards, stout oak crossbars are fixed so as to leave an inch or two clear between their underside and the bottom of



the culvert, and on these crossbars are arranged three or more glass insulators, corrugated on the outside of the cup to increase the length of surface, and notched at the top to make a recess for the conductor to rest in, this latter being formed of one or more strips of copper, 1 inch wide by ¼ inch thick. The culvert is covered by flagstones, and above them again comes the ordinary paving of the footway. At each set of insulators a manhole, with cover, is provided to give access to them. At intervals, depending on the lengths of the copper strip, straining gear is provided in the manholes, the arrangement for each conductor consisting of a gunmetal bridge, the feet of which rest against insulators fixed on crossbars. This bridge has a rectangular hole through which the conductor passes and in which it is firmly clamped by set screws. The conductor having been put in place, one end of it is clamped in a bridge, whilst the other end, having been passed through the hole in the bridge at the further manhole, is attached to a screw tightening gear, by means of which it is strained up tight before being clamped in the bridge. As these culverts occupy a space under the footway of two to three square feet in area, there are many places where it is impossible to find room for them, and when this is the case vulcanised rubber cables drawn into wrought iron pipes are used. Connections are made between the cable and the bare strip by soldering a lug with a projecting tongue on to the cable, and fixing this tongue and the copper strip, both of which are tinned first, in a clamp. Joints in the copper strip are made by tinning the ends and clamping them together.

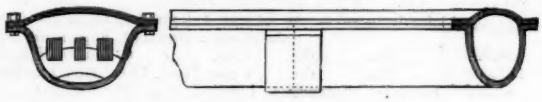
The Westminster Company's mains, as first laid, were on Crompton's system, as just described, but the bare copper mains now being laid



down by this company are being laid on a system devised by Professor Kennedy, which has in my opinion, considerable advantages over the earlier system, inasmuch as it has been designed as a drawing-in system, and the culvert does not occupy so much space, being of about the same width, but only 7½ inches deep inside. The culvert, which is built of concrete, is wider at the top than at the bottom, a ledge being formed on each side about 4½ inches up. Bedded in the concrete at intervals of six or eight feet are stoneware insulators, notched at the top to receive the conductors, which are built up of strips, 1 inch by ¼ inch. This copper strip is straightened on the pavement by a pull from a special tool devised for this purpose, and is then drawn into the culvert, being attached to a carriage which running on the ledges already referred to, is hauled through from the further manhole. Where there is not room for this culvert vulcanised rubber cables in iron pipes or Callender-Webber casing are used. The copper strips can be obtained in lengths of about 180 feet, and joints between two lengths of strip, or between the strip and the cable are made as already described. Service boxes are generally placed for every alternate house, and service connections are made with rubber cables in iron pipes.

In addition to the mains already described, there are some feeding mains of Siemens armoured cable, which is laid in the ground direct, merely being covered with a board, about 6 inches wide, to indicate its presence. The joints in these cables are made in boxes filled with oil, as already described.

The St. James's and Pall Mall Company also use a bare conductor system, which, however, differs a good deal from those of Crompton and Kennedy. The culvert consists of a flanged cast iron trough about 10 inches wide by 6 inches deep, in section like half an ellipse. These troughs are about 3 feet 6 inches long, and are connected by short pieces about 5 inches or 6 inches long, of similar shape, which are fitted to the outsides of the troughs, and the joint run in with lead. Glazed earthenware bridges, with three notches for the con-



ductors to rest in, are fixed in these troughs, at distances of about 9 feet, and in the notches are laid copper strips, each 2 inches by $\frac{1}{10}$ inch, placed on edge, and straightened with a mallet. Over the top of the conductors a second set of earthenware bridges is placed to keep them in position. A flanged and slightly arched cover is then bolted on the top, the joints between the cover and the trough, and between the lengths of cover and the butt strips which joint them being made with red lead and yarn Brick manholes are built at about every 100 feet, and are connected to the drains, and the troughs are laid with a dip towards the manholes. When connection cannot be made to the drains, arrangements are made to pump out any accumulation of water. At each manhole the conductors are connected by removable clamps. House services are made with rubber cables in wrought iron pipes, these latter being screwed into the trough, and the cables soldered to the copper strips.

This system has the advantage that the culvert takes up much less room under the pavement than a brick or concrete culvert, but it is essentially a built-in system, and once laid, access can be got to the conductors only by digging up the trough.

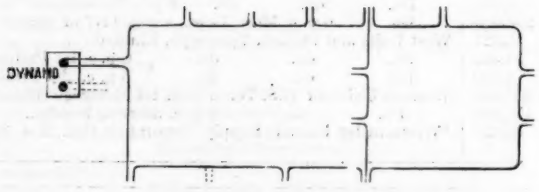
The Electricity Supply Corporation use Callendar bitite cables laid in Callender-Webber casing, and in this case the precaution is taken of placing an inverted iron trough over the casing, so that it is protected at the top and sides from mechanical injury.

The Metropolitan Company, for their low pressure distribution from the Whitehall Station, also use Callendar cables. These are laid in Northumberland Avenue in the subway, and elsewhere in Callendar-Webber casing.

The Chelsea Electricity Supply Company, though not working an entirely low pressure system, may be taken here, as the greater portion of their mains are for low pressure. They have, however, one charging main which connects all their sub-stations to the generating station, and in this main the pressure is 1,500 volts. The cables used throughout are bitite cables, drawn into Callender-Webber casings.

We come now to the high pressure systems, in all of which alternating currents are used, with transformers on the consumers' premises.

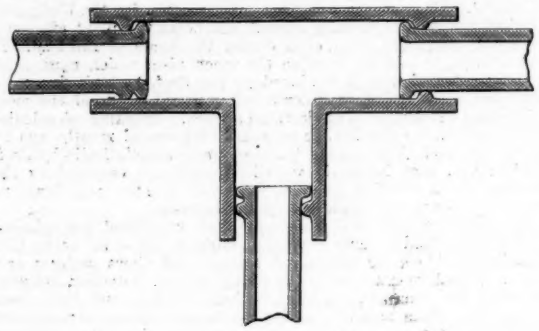
The Metropolitan Company distribute current, at a pressure of 1,000 volts, from their stations at Sardinia Street, Rathbone Place,



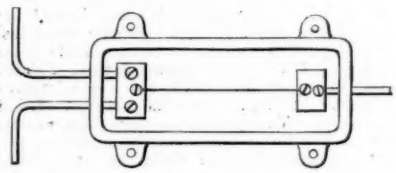
and Manchester Square. The mains consist of high class vulcanised rubber cables, drawn into cast iron pipes. Surface boxes are provided at corners, and elsewhere as required, to facilitate the drawing in or out of the cables, and split T-pieces are inserted in place of the ordinary pipe when required for connection to consumers' premises. This system has been planned in such a manner that every consumer has a double service from the station, and so that sections of mains can be disconnected for testing, or connections made to new premises

* Lecture delivered before the Woodhouse and Rawson *employés* class, March 6th, 1891.

without stopping the supply to other consumers. The method by which this is effected is as follows:—The current leaves the generating station by a number of mains, each of which forms a complete loop, so that, as both ends are connected to the dynamos, there are always two distinct circuits between the dynamos and any consumer. If a branch is taken off this main, it is also arranged as a loop returning to the main again. House services are not made by taking off T-branches in the usual manner, but the mains, themselves, are run into the house and out again, the ingoing and outgoing cables being fixed to the same block on the primary circuit cut-out. It will be seen

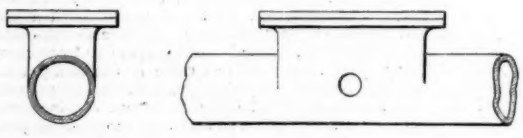


from this that the main consists of a number of comparatively short lengths of cable, which are connected to one another at the terminals of the cut-outs, and that any one of these lengths of cable can be disconnected and removed without stopping the supply to any house. This gives great facilities for testing for a fault, and permits of a faulty length of cable being pulled out and replaced by a new length without inconvenience. It also allows a fresh connection to be made, as suppose that in any street Nos. 5 and 21 are con-



nected up, and that No. 13 wants to be connected. The cables connecting 5 and 21 are drawn out, the two houses in the meanwhile getting their supply one from each side of the loop; and a pair of cables are drawn in to connect 5 and 13, and another pair to connect 13 and 21. In addition to the distributing system from each station, the three stations are connected together by trunk mains, each consisting of four pairs of rubber cables in a cast iron pipe, so that, if necessary, one station can help another, or all the lights on the three systems can be supplied from one station at times of minimum consumption.

The House-to-House Company at West Brompton, working with a pressure of 2,000 volts, have also adopted cast iron socket pipes for their conduits, into which are drawn well insulated vulcanised rubber cables. Cast iron surface boxes are placed at all bends and places where branches are taken off, and special lengths of pipe are



fixed opposite every alternate party wall. These special pipes are enlarged into boxes which are U-shaped in section and have a flat lid fixed by a clamp, and in these the house service wires are jointed to the mains. All the joints in this system are insulated with India-rubber which is vulcanised in *situ* in the manner already described.

The London Electric Supply Company, working at a pressure of 10,000 volts, between Deptford and London, use the Ferranti main, the methods of making and jointing which have already been described. From Deptford to London Bridge the route followed is mostly along the railway, and here the mains are fixed on the outside of the railway boundary wall. Elsewhere they are laid in the ground, either direct or in a trough filled in with compound. From the sub-stations in various parts of London to the consumers' premises, a pressure of 2,400 volts is employed, and for this two or three kinds of cable have been used. For some years, mains consisting of vulcanised rubber cables in iron pipes have been in use in addition to the overhead cables, by means of which the greater part of the distribution from their old station at the Grosvenor Gallery was effected. I understand now, that it is proposed to use concentric cables throughout the whole system, and that these cables will therefore be made concentric. In addition to this, during the last year Siemens concentric armoured cable has been laid in various districts, and at the present time some Fowler-Waring concentric cable is being laid.

Before concluding, I feel that I must say a few words on the subject of the testing of cables, more especially as this is a point which has, I think, been rather too much overlooked. Notwithstanding the fact that the cost of the underground system of mains is a most important item in any central station undertaking, we still find that a great deal more attention is paid to the subject of testing the machinery, &c., than is paid to that of testing the cables, and that very few people seem to trouble themselves to see that cables are rigorously tested before delivery. I consider that the testing of the cable before delivery under definite specified conditions is most important; for instance, for all cables to be used with high pressure, I would suggest that a test be taken with 500 or 600 volts the cable being immersed in water, and that then the cable should be subjected to a pressure at least as great as that at which it is to be worked for a certain number of hours, after which the test with 500 or 600 volts should be repeated to see if there is any falling off of insulation. Again when cable is being laid, each section should be tested before any joints are made, and the test repeated as each fresh joint is included in the circuit. By this means it is possible to follow the behaviour of the cable right through, and to detect at once if any injury has been done to the cable in laying or if a faulty joint has been made, and to have the same put right; whereas if no tests are made, or they are not made until the system of cables is complete and a fault exists it is often a difficult matter to localise it.

When mains are laid and in use, it is important that a continuous test should be kept up whilst the current is on, so that any change in the insulation may be noted at once. Various methods of doing this are in use according to the system of working, *e.g.*, on a low pressure system each conductor may in turn be connected to earth through a lamp of small candle-power, and the leakage judged of by whether the lamp glows or not. This is of course a very rough test and is only applicable when the insulation is low, but it is very convenient for detecting changes in insulation resistance, and has the advantage of great simplicity, so that it can be made by any station attendant. An actual measurement of the insulation resistance may be made if a high resistance voltmeter is substituted for the lamp mentioned above, and readings are taken first of the potential difference between the two conductors and secondly of the potential difference between each conductor and earth. If we call these three readings V, V^1, and V^2, respectively, and the voltmeter resistance R, then the insulation resistance, R^1, of the positive conductor $= \frac{R(V - V^1 - V^2)}{V^2}$ and that of the negative conductor is $R^2 = \frac{R(V - V^1 - V^2)}{V^1}$ The highest resistance = 10 times voltmeter resistance. The highest insulation resistance that can be measured in this way is generally about ten times the voltmeter resistance. It will be seen from these values that the insulation resistances are proportional to the voltmeter readings between earth and the conductors, and if a very high reading is obtained on one and a very low reading in the other conductor, it shows that there is a fault of considerable magnitude on the latter. This is sometimes measured by connecting the first conductor to earth by a low reading ammeter and obtaining the insulation resistance by dividing the volts between the two conductors by the ampères or fraction of an ampère which passes.

Another method is to form a Wheatstone bridge by means of the two leakage resistances, a known fixed resistance, R, and an adjustable resistance, the galvanometer being connected between earth and the junction of the fixed and adjustable resistances. By adjusting until a balance is obtained the ratio between the two insulation resistances is found, say $\frac{x}{y} = \frac{\rho}{R}$ where ρ is the value of the adjustable resistance. Now connect a known resistance, R_1, between earth and the conductor whose insulation resistance we have called x, and again obtain a balance this time with ρ_1 ohms in the adjustable resistance, then $x = \frac{R_1}{\rho_1}(\rho - \rho_1)$.

Owing to the difficulty of getting voltmeters or lamps which can be used with high pressures, the methods mentioned above have to be modified before they can be used on circuits working at high pressure. For continuous currents a number of lamps in series or a voltmeter with a large added resistance may be employed, and for alternating currents a transformer may be used, the primary circuit being connected between a conductor and earth, whilst the secondary circuit is connected to a lamp or to a non-inductive voltmeter. Another method is to substitute for the lamp a vacuum tube placed inside a darkened box, the terminals of the tube being connected respectively to earth, and to the conductor under test. In this method, if the insulation is good, there is a visible glow due to the discharge through the tube, and this glow diminishes in brightness as the insulation resistance becomes less, thus giving an indication of the state of the mains.

Although the methods mentioned above are sufficient to indicate the presence of a fault on the circuit, they cannot tell more about its position than that it is on one particular side. In order to localise a fault by testing, it is always necessary to know the true conductor resistance of each part of the circuit, and this is practically impossible in a network of conductors, when the two sides are connected together by a number of lamps, transformers, or other apparatus. There are special cases in which a fault of low resistance may be localised by testing from the station, but in the majority of cases this is practicaly impossible, and herein lies one of the great advantages of a system like that used by the Metropolitan Company, and by several companies working low pressure systems, when the mains are so arranged that they can be easily divided up into a number of separate

small sections, each of which may be tested by itself. Again should there be two distinct faults causing the leakage, then, even in the special cases which allow of one fault being localised, the position indicated by the test would be the position of the resultant fault, that is a position somewhere intermediate between the two faults, where very likely the insulation of the mains may be very good. There is one method which has been used by one or two companies, which consists in wheeling along the route of the main a trolley carrying an iron plate on which is wound a coil of wire connected to a telephone, whilst an alternating or pulsating current is sent into the conductor. It is said that when near the fault there is a distinct change in the character of the sound emitted by the telephone, and that faults have been successfully localised by this means. I have never myself had an opportunity of trying this method, but should think that although the proximity of the fault will change the sound, yet owing to the numerous other conditions in and under our streets which might also change the sound of so delicate an instrument as a telephone, there is a very good chance of discovering faults which have no existence, except in the telephonic apparatus itself. Failing this method, and in the present state of our knowledge, or want of knowledge, on this subject, it is probably best to arrange the circuits in such a way that they can be easily sub-divided, and that the faulty section when found can be pulled out and replaced by another, without stopping the supply of current to any, or at the worst to more than one or two customers.

In conclusion I would wish to draw attention to the fact that in the majority of cases, underground mains are as yet in their infancy, and that therefore the practical experience which will be gained during the next five years or so will probably add very largely to our knowledge of the subject, as the advantages or disadvantages of the various methods are emphasised by the test of actual use.

PROCEEDINGS OF SOCIETIES.

Institution of Electrical Engineers, March 12th, 1891.

ADJOURNED DISCUSSION ON MR. SWINBURNE'S PAPER, "TRANSFORMER DISTRIBUTION."

[*Authorised Abstract.*]

MR. A. P. TROTTER said the author had been criticised for giving figures instead of facts. This criticism he considered unfair, for it was better to give figures early enough to prevent serious mistakes being made. Had Mr. Swinburne's paper on "Armature Reactions in Direct Current Dynamos" appeared sooner, it would have saved others from falling into error in making large Gramme armatures for constant current machines. On the subject of transformer tests, he said the calorimeter method, to be at all accurate, involved many troublesome corrections, and would require very large vessels. The electrostatic wattmeter methods need to be tried. Split dynamometers neglected leakage, and as the stray fields are quite different to what one would expect, serious errors may be introduced. Dr. Fleming's experiments at the Royal Institution illustrated what peculiar effects were produced by alternating fields. In such fields copper behaved very much like iron in ordinary fields, and possibly copper filings might prove useful for exploring the waste fields of transformers. Mr. Mordey's thermometer method would, he thought, involve considerable trouble if anything like accurate results were to be obtained, for since the heat was in one case generated in the iron and in the other in the copper, the fact that a thermometer on the iron gave the same reading did not necessarily show that the energy dissipated in the two cases were identical. To obtain reliable results the distribution of temperature should be uniform, and the isothermal surfaces parallel to a casing surrounding the transformer under test. The two latter methods, curiously enough, led to the result that the losses in hysteresis become less as the load increases. This he could not understand, for if, as is generally assumed, the induction is constant at all loads, he failed to see what goes on in the transformer which would explain the new fact. Since the last meeting, two valuable contributions to our knowledge of transformers had been read before the Physical Society. On the subject of the diminished iron losses at large loads referred to in one of these papers, he would ask whether such a result was consistent with Ewing's theory of magnetism. To him it appeared possible that the losses with rapidly alternating currents may be quite different from those existing for slow cycles. In order to illustrate the fact that physical properties of materials depend on the rapidity of the changes influencing them, he showed that a piece of pitch, which was quite soft and viscous to steady pressures, yet transmitted the rapid vibrations of a tuning-fork like a rigid body.

Mr. G. C. FRICKER, referring to comparisons of closed and open circuit transformers, said that in estimating the loss in a closed circuit one as 120 watts, Mr. Swinburne was in full accord with writers and teachers who hold that the magnetisation is constant at all loads. This assumption was, however, challenged by Mr. Mordey at the last meeting, and he himself doubted its truth. Great confusion, he said, existed amongst recognised authorities in the theory of the subject. Mr. Kapp, for instance, in his diagram illustrating the actions taking place in a closed circuit transformer, builds up his component forces on a line drawn to represent the maximum value of the resulting induction, and, in the speaker's opinion, thereby begs the whole question. He also asserts that the resulting induction is in quadrature with the secondary current, because this current is in consonance with the impressed E.M.F. Mr. Blakesley, starting from a different standpoint, viz., the impressed primary force, and assuming the necessary adjustment of primary and secondary currents, arrives at the conclusion that the secondary impressed force is in quadrature with the primary current. If, therefore, both Mr. Kapp and Mr. Blakesley are right, the phase difference between the primary and secondary currents is always 90°. He (Mr. Fricker) thought one of the statements must be wrong, and asked Mr. Swinburne to point out which was correct, or to reconcile the two. In view of the contradictions between recognised authorities on the theory of transformers, he thought the experimental facts brought forward by Mr. Mordey should not be lightly set aside. So far as these results would affect the comparison of closed and open circuit transformers, Mr. Swinburne might say that the open form would be equally benefitted if the new view be correct. He, however, could not agree to this, for the Hedgehog required a very large exciting current, and hence the plant efficiency would be materially lower, even during the hours of full load. It was difficult, he said, to conceive the mechanism which must exist within the transformer if Mr. Mordey's and Prof. Ayrton's figures be true; but, nevertheless, their confirmation would be one of the most interesting developments of electrical science. Speaking of calculations based on the sine law, he remarked that several months ago he arrived at conclusions similar to those proved analytically by Prof. Ayrton, viz., that harmonic variations were not essential to the accuracy of the resulting formulæ, and would give the considerations which led him to the conclusions in the Journal.

Dr. FLEMING said Mr. Swinburne had ventilated his opinions against the orthodox views of parallel working, but so far as he (Dr. Fleming) could see, he merely put forward old views under a new name. Armature reactions really meant mutual induction between armature and magnets, and as such their existence had always been recognised. Considerable attention, he thought, should be paid to the state of a system at a given instant, and a distinction drawn between the instantaneous inductance and the mean inductance of a circuit. Referring to Prof. Ryan's "Indicator diagrams for Transformers," where the E.M.F. and current curves are plotted in correct relative positions, he showed how the inductance at any instant could be obtained, and expressed it by the formula:

$$\text{I} = \frac{e - r\,i}{\frac{d\,i}{d\,t}},$$

e being the E.M.F., i the current, and $\frac{d\,i}{d\,t}$ the slope of the current curve at the point corresponding to the instant considered. Inductances so found were, he said, periodic functions of time. On the subject of parallel working, he thought little or no advance had been made since Mr. Mordey's paper was read. Parallel working was then shown to be quite practicable, and is now largely employed on the continent. At Leghorn several 150 H.P. alternators work perfectly in parallel. These machines have high resistance, small time constant, and stiff field, the conditions which, according to orthodox views, are desirable. He could not agree with Mr. Swinburne that 1,000 volts station pressure was preferable to 2,000, for the cost of the mains in the latter case was only about half that in the former. The employment of 2,000 volts did not seem to be any more dangerous, for Messrs. Ganz & Co. and the Thomson-Houston Company had many stations working at this pressure, and so far as he had observed, the 2,000 volt alternators required no more care in working than their low pressure exciters. He doubted whether the use of low pressure alternators and step up transformers would be safer or more economical, for the waste in the transformers would be considerable, and their cost would probably far exceed the figure quoted by Mr. Swinburne. The chief claim made for the Hedgehog form of transformer was that it gave a more square-shouldered efficiency curve than the closed type. Whether this was so or not, was, he said, a question of calculation, but one on which experiment alone could decide. Such experiments should not be made by a wattmeter where a fine coil and non-inductive resistance were employed, for considerable error may be introduced. Although Mr. Swinburne admitted that the Hedgehog transformer required a large exciting current, he seemed to under-rate the effect of this, when a number of small transformers were connected up, for it would entail a great waste of coal and lower the plant efficiency. As regards sub-centres and low pressure distribution, he said nothing could be more charming when writing a paper, but when one came to devise a practical system to work under present conditions great difficulties presented themselves. Care should, however, be taken to run the feeders for supplying high pressure distributors, so that they terminate at points where sub-stations may subsequently be conveniently placed.

Mr. KAPP thought the efficiency of the Hedgehog transformer would be increased by closing its magnetic circuit, for this would reduce the exciting current, and by diminishing the magnetic resistance the lag would be increased; therefore the power would be less, and the plant efficiency greater. He could not see how it was possible for an open circuit transformer, which required a large exciting current all the day, to be more efficient than a closed circuit one. The matter could not be settled by argument, and experiments must be appealed to. Speaking of sub-stations, he said he was disappointed with Dr. Fleming's view, for the system had taken great hold upon engineers. At present, however, it would be futile to build large sub-stations. Eventually a leaf might be taken out of the book of direct current engineers, and stations to supply limited districts established. But, instead of carrying coal to these stations, they would convey electric energy. Distribution could then be effected much more economically, for large or small transformers could be put in or out according to the demand. He called attention to a drawing of an automatic apparatus for performing these operations which he had designed, and said a copy would appear in the Journal.

Mr. F. KING agreed with Mr. Swinburne about the defects of the house transformer system, but thought his estimate that the average consumption amounted to half load for four hours per day was rather

too high; three hours half load would be nearer the truth. Making this correction, the all-day efficiency becomes considerably less than the least figure given in the paper. Referring to the advantages of storage, he said secondary batteries were now satisfactory things, and believed that when transformer systems could use storage, then alternate current engineers would appreciate its importance in reducing working expenses.

Mr. S. JOYCE, jun., asked whether the iron losses in transformers, obtained from Mr. Mordey's and Prof. Ayrton's experiments, continued to decrease with increase of load, and if they ever became zero or negative.

Major CARDEW said people's opinion differed considerably as to what was meant by sub-stations. Mr. Kapp's system was expensive, but he saw no reason why transformers should not be placed in small lean-to buildings, and used to supply several houses in the neighbourhood.

Prof. S. P. THOMPSON hailed with satisfaction Mr. Swinburne's opinion about 1,000 volts being generally preferable to 2,000. Dr. Fleming had said that the cost of the mains varied inversely as the volts. As far as copper was concerned this might be correct, but it was not so for insulation. This, he thought, varied as the square of the volts, whilst compensations, &c., might be as the fifth or sixth power.

Mr. MORDEY, replying to Mr. Joyce, said the efficiency curve rises and then falls again, whereas the iron losses fall to a minimum, and then rise with further increase of load. Many tests show the same result. On the subject of armature reactions, he had experimented by isolating one coil of a 50 H P. armature from the rest, and connecting it with a voltmeter. On varying the load from 0 to 20 ampères, this voltmeter remained quite stationary, whilst the pressure of the active coils fell 6 or 7 per cent. Referring to Mr. Trotter's objections to his thermometer method of testing transformers, he said magnetic leakage could not affect the result at all, and with care, there was no difficuly in obtaining correct results.

Prof. AYRTON did not agree with the author's remarks on slip 4 about the word "self-induction" being meaningless when applied to an armature, and pointed out that the self-induction of a coil was not affected merely by its being interlinked with lines due to other magnetising forces. The self-induction of a coil meant the change of lines threading the coil due to unit current in that coil, and although its value would be affected by the presence of iron, yet under given conditions its meaning was quite definite. The transformer tests made by Mr. Taylor and himself had, he said, been attacked both because they gave a point of maximum efficiency and because they showed the loss in iron to be small at full load. No doubt Prof. Ewing and Dr. Hopkinson had shown what the losses were when iron was subjected to slow changes of magnetism, but so far as he knew there was no proof that the same losses occur with rapid reversals. In a number of *La Lumière Electrique* for March, 1890, Prof. Roiti had given results of transformer tests made by different methods to those employed by Mr. Mordey and himself, and had been led to the same conclusion, viz., that at moderate loads the iron losses in transformers were negligible. Three independent observers using different methods had thus been led to the same conclusion. Speaking of measuring power, he said Dr. Sumpner and himself had communicated to the Royal Society a new and simple method quite independent of any assumptions as to harmonic variations or leakage, and at an early date he proposed making tests on both closed and open circuit transformers by this method.

Mr. SWINBURNE, in replying to Mr. Esson, said Dr. Hopkinson had worked out the best conditions for parallel working by getting the greatest control for a small change in the lead or lag angle on the assumption that two equal machines were in parallel. This, he pointed out, was not the condition which holds in practice. To Mr. Evershed he pointed out that there was no difficulty in redressing the main current for series excitation of an alternator, for this was done daily by Thomson-Houston and Ganz. He then observed that though it was said that his representative closed circuit transformer was not good enough, he had repeatedly asked for particulars of a better one, but they had not been produced. Though he had done so in his B.A. paper, he was not now called upon to design closed circuit transformers for his opponents, and in his present paper he had taken a commercial "Hedgehog" and had compared it with a commercial closed circuit transformer. His "freezing mixture" statement, he said, was not based on Ewing's curves, for he found that, according to Ferrari's tests, the loss in the whole transformer was less than the loss by resistance, and so the iron must have actually supplied power to the circuit. The readings were taken by the "split" dynamometer method, and proved its worthlessness. Mr. Mordey's figures were, he said, shown to be inaccurate by their agreement with those of Prof. Ayrton and Mr. Taylor, which were taken by the split dynamometer method, and thus gave too high efficiency, especially at full load. Whether the iron losses become small or not at full load was, he said, of little importance to his contention, for if it be admitted that they are large at no load, his point as to the superiority of the open circuit type was proved. Any wattmeter would not give accurate results in transformer measurements, and before one is used it should be carfully checked both with direct and alternating currents on resistances and choking coils. As it was very important that people should have confidence in transformer tests, his firm would provide all apparatus for different tests to be carried out on the same transformers by all the well-known methods, and he hoped a good closed circuit transformer would be forthcoming to undergo the same tests. He would be glad if Profs. Fleming or Thompson would make the tests, everything being provided for them. Mr. Kapp's and Mr. Esson's argument that a Hedgehog would be improved by closing the iron circuit was, he said, bad, for that would double the iron loss The large exciting current was not a serious matter, for, although speakers had overlooked the fact, this could be supplied by condensers or by a dynamo running loose. On the subject of sub-stations, he pointed out that there was no need for buildings, for transformers might be sunk in the roadway where needed. Neither was there any necessity for automatic switches to cut transformers in and out, for if properly designed they could always be left on without appreciable waste.

LONDON COUNTY COUNCIL.

AT the weekly meeting in Spring Gardens, the Offices Committee reported the following:—

LONDON ELECTRIC SUPPLY CORPORATION, LIMITED.

"We have had before us an application from the London Electric Supply Corporation for permission to lay down a main through the yard at the back of the council's offices for the purpose of connecting the corporation's station in Red Lion Yard with the main proposed to be laid along Carlton Gardens and St. James's Park to Pimlico. We see no objection to the application being granted on certain conditions, and we accordingly recommend:—(*a*) That the council do consent to the London Electric Supply Corporation carrying a main through the back yard of the council's offices from Red Lion Yard to Carlton Gardens, on the following conditions, viz., that a rent of £1 per month be paid for the privilege; that the corporation do also obtain a license from the Crown to lay down the main; that the main be laid and the work carried out to the satisfaction of the architect and chief engineer of the council, and on such other conditions as the architect and engineer may think necessary; that the corporation at its sole cost do make good any damage that may be done to the premises in carrying out the work, and remove the main within two calendar months on receiving notice from the council. (*b*) That the solicitor be instructed to prepare an agreement embodying the foregoing conditions.

ELECTRIC LIGHTING OF CLAYBURY ASYLUM.

The Asylums Committee said: "We have received a report from the Claybury sub-committee to the effect that they have exhaustively considered the question of lighting that asylum by electricity, and are unanimously of opinion that on the grounds of efficiency, safety, convenience, healthiness, and cleanliness electric lighting is the best system that can be adopted, and that it may ultimately prove to be the most economical. A scheme of lighting by electricity has been prepared by Mr. Gunyon, the head assistant of the council's electric lighting staff, in conjunction with Mr. Hine, the architect of the asylum. This scheme, which has been approved by the Claybury sub-committee, and a copy of which we have directed to be sent to every member of the council, will be found to contain full details of the proposed system of this method of lighting and its estimated cost. The initial cost would probably be more than that of gas—say £17,500, as against, say, £15,000. The annual cost would at present be somewhat more, but ultimately less. We would remark that this form of lighting the asylum is favourably regarded by the Commissioners in Lunacy, and that it has been in use at the Exeter City Asylum for the last five years with success. It will be desirable to provide gas mains in addition to the electric light, for cooking purposes, and for lighting the gas entrance lodges and main roads, at a cost of, say, £1,000, which amount is already provided for. It is essential that this question should be settled at once, and we now recommend that, subject to an estimate being submitted by the finance committee, we be authorised to take the necessary steps to provide electric lighting at a cost not exceeding £17,500."

EFFICIENCY OF TRANSFORMERS.*

BY E. WILBUR RICE, JUN.

I NOTICE in the *Electrical World* of February 21st, an article on "The Efficiency of Transformers," by William Stanley, Jun., giving some data on the maximum efficiency and losses of several transformers, which transformers are said to be of the latest design of the various manufacturers.

As this comparison places the Stanley transformer at the top of the list and makes a correspondingly poor showing for the Thomson-Houston transformer, I thought your readers would be interested in obtaining some results of tests of the tranformers which have been manufactured by the Thomson-Houston Electric Company for some time past; and while it is understood that these figures may be open to the objection of *ex-parte* statements, they are certainly no worse in that respect than the information contained in the article mentioned.

The following table, prepared by Mr. Axel Ekstrom, who has charge of this special line of work for the Thomson-Houston Company, gives some data on the transformers

* *Electrical World.*

which are now and have for some time past been regularly manufactured by the Thomson-Houston Company :—

Nominal capacity, light.	Normal output, watts.	E.M.F., primary.	E.M.F., secondary.	Ratio conversion.	C^2R., total.	Iron loss, total.	Drop in secondary.	Maximum efficiency.
10	600	1,040	52	20	11·97	46·5	1	91·5
15	900	1,040	52	20	18·86	59	1·2	92·2
25	1,500	1,040	52	20	30·40	59·6	2	94·5
40	2,400	1,040	52	20	57·80	73	2	95
75	4,500	1,040	52	20	72·30	144	1·6	95·5

The method of testing these transformers is the same as that mentioned by Mr. Stanley, and the frequency is 125 periods per second.

In order that the public may have the benefit of tests which will be recognised as entirely free from the faintest suspicion of prejudice, the Thomson-Houston Company has forwarded to the Massachusetts Institute of Technology, for careful tests, a complete line of transformers taken from stock, and the results of these tests, as soon as received, will be duly published.

CORRESPONDENCE.

Storms and Telegrams.

I have read with some interest the articles being published in your paper, entitled, "Storms and Telegrams," by W Slingo and A. Brooker, and I cannot help but wonder what these gentlemen would think if they had to operate and maintain lines of telegraph under such conditions as exist in this country.

The Canadian Pacific Railway Company's line of telegraph extends from Canso, in Nova Scotia, to Vancouver, in British Columbia; and thence through Washington, Oregon, and Northern and Southern California to Los Angeles, making a distance from Canso to Los Angeles of about 5,500 miles. Along this route, for a very large proportion, the lines run through an unsettled country, and where every varying condition of climate, at one time or another, prevails. At the eastern, of Nova Scotia end, the rain freezes, and forms a crust on the wires sometimes three and four inches in diameter. At other sections of the line north of Lake Superior, the thermometer drops down sometimes to 30 or 40 degrees below zero, causing sudden and sharp contraction.

In the mountains of British Columbia, the snow falls quietly and lazily until the cross arms and insulators have sometimes 6 and 7 inches of snow heaped upon them, so that the telegraph lineman has to remove this snow, otherwise it would weigh the wires and poles down, causing both to give way.

Between Vancouver and Seattle, until within the past few months, 150 miles practically ran through a forest, with trees from 200 to 250 feet high and from 40 to 50 feet in circumference, the roots of which had such very little hold in the ground that every wind-storm brought them down by the dozen, and the linemen who repair the wires were frequently puzzled as to whether it was easier to walk round or climb over these obstructions, no progress, except on foot, being possible.

The same condition, more or less, existed in Northern California, while in Southern California, of course, the climate is of an entirely different nature.

Notwithstanding all these difficulties, the telegraph line between Canso and Los Angeles is scarcely ever interrupted, except during the most disastrous storm, for more than several hours at a time. Such a condition of affairs as is particularly mentioned as having occurred on the night of December 26th, 1886, and which prostrated the telegraph service in the vicinity of London, is a common occurrence in this country, and does not cause any very great or widespread disaster.

In the first place, we see that the telegraph poles which carry the wires are very strong, and able to bear their weight. We place them 30 or 45 to the mile, and see that the earth around them is well tamped. Every curve is well braced. Our cross-arms which carry the wires, our top-pins which hold the insulators, and the wires themselves, are all specially designed to meet these conditions. A copper wire could not be used to advantage.

The linemen we employ, and the section men along the railroad (who are supposed to do temporary repairs in the absence of the regular men), could not be expected to handle the copper wire with the care that is necessary in order to prevent any indentations in it. In fact, we have to provide for this contraction and expansion, between the very warm summers and the very cold winters, and it is a question with us whether it is wise to solder the joints that are made, for if the soldering is not done most carefully and skilfully it is apt to burn the wire, causing it to be more brittle, and therefore more liable to snap during the sudden changes of temperature that prevail.

We cannot but feel that the English engineer, working in a country that is so thickly settled, and where the distances are comparatively very small, has a very easy task, as compared with what the engineer in this country has to contend with, who builds his telegraph line years ahead of the settlement of the country, through forests, and over mountains, where he has to meet conditions that must be unknown to the engineer whose work is confined to such a section as is comprised in Great Britain.

Chas. R. Hosmer.

Manager Canadian Pacific Railway Telegraphs.

Montreal, February 25th, 1891.

In Reply to M. de Fonvielle.

Having, by your courtesy, examined the letter of M. Wilfrid de Fonvielle, the authorship of which I was disposed from internal evidence to doubt, I desire to say that I no longer doubt its genuineness. I trust that M. de Fonvielle will forgive me for having poked a little fun at its contents. His letter of the 9th inst., though it does not clear up the mystery how he came to suppose that I had altered my lecture about Sturgeon, shows that we do not really differ greatly. He admits frankly concerning Sturgeon that "he saw a great and startling fact which had escaped the notice of Ampère and Arago." What plainer recognition could one desire? The laurels so well earned by Ampère and Arago are in no sense endangered by granting to Sturgeon a recognition of his merits in a less ambitious but more practical sphere.

Silvanus P. Thompson.

March 16th.

In Reply to Mr. Sykes.

Mr. Sykes must pardon me if I suggest that he does not quite understand my letter on which he comments. M. de Fonvielle's first letter was, from some cause or other, so contradictory as to make it impossible for me to believe that it was from his pen. The gist of that letter was that in the first of my Cantor lectures on the electro-magnet I had omitted to give credit to Ampère and Arago, whose work in electro-magnetism preceded that of Sturgeon, and that as the result of some representation made by him (which I have never been able to find), I had altered the part relating to Sturgeon, so as to make it appear that Sturgeon had invented *horseshoedness*. Now what Mr. Sykes does not, I think, understand, is that my good friend M. Wilfrid de Fonvielle had discovered a mare's nest. For the facts are these : In the first place I have not altered my Cantor lecture since its delivery. In the second place, so far from omitting to mention Ampère and Arago, I referred expressly to their prior work. In the third place I have never claimed the invention of *horseshoedness* for Sturgeon : this would be absurd in the face of the abundant use of horseshoe steel magnets during the preceding century. I trust, therefore, that Mr. Sykes will do me the simple justice of reading exactly what I did say about Ampère, Arago and Sturgeon. I think he

will then withdraw the charge of unfairness which he has made whilst under the impression that I wrote something which I never wrote, that I retracted something that I never retracted, and that I altered something that I never altered. What I wrote I wrote. *Litera scripta manet.* Pray let me be judged by what I wrote, not by something which somebody else erroneously thought I wrote, or altered, or retracted. As to unfairness, if it be unfair to give references to the original documents (as I did), rather than to take my information from second-hand or third-hand sources, then I plead abundantly guilty of that species of offence.

Silvanus P. Thompson.

March 16th, 1891.

In Reply to Yourselves.

The usual custom (honoured in the breach, as I perceive, in your pages by Mr. Biggs) of not replying to editorial articles can scarcely apply when the editors step down into their own correspondence columns to take sides in a controversy. I meet this departure by departing in turn from the usual abstinence, and beg to offer a brief rejoinder to the editorial contribution on page 352.

I am quite aware of the machine exhibited at South Kensington Museum; but I am not so utterly simple as to swallow the notion that because somebody sends a machine to be exhibited in a museum, therefore there never was an earlier machine. And I repeat, what I have already said, that the claim that this is the first self-exciting machine stands solely upon Mr. S. A. Varley's assertion. To disprove my point it is only necessary for you to show (1) at what date this machine was constructed; (2) that none of the other machines before that date were self-exciting. I am correct in saying that down to the present moment this has not been done.

But why, gentlemen, do you not permit this issue, which Mr. S. A. Varley has thus trailed across the path, to rest until the other matter is settled? If you desire me to furnish the proofs I shall be happy so to do, so soon as Mr. S. A. Varley has admitted his blunder and retracted his slander on the late Prof. Jenkin. Until he does so, it is obvious that no one need attach any weight to any assertion of his.

Silvanus P. Thompson.

March 17th, 1891.

[Professor Thompson seems to have forgotten that in the Edinburgh case Mr. Varley's assertions on a closely allied matter carried the day, notwithstanding the array of professorial evidence against him.—EDS. ELEC. REV.]

Self-exciting Dynamos.

I think it will be generally admitted that no scientific advance has had such immediate revolutionary consequences as the discovery of the reaction or dynamo principle first made by myself in 1866, and shortly afterwards independently discovered by Messrs. Siemens and Wheatstone. The following passages occur in Dr. Silvanus Thompson's letter, which appeared in your last issue:—"As for his (Varley's) nonsense about his 1866 machine being the first self-excitng dynamo constructed, what on earth has that, or my refusal to admit into the rank of established facts a claim that stands solely upon Mr. Varley's own assertion, to do, &c." "In vain does he trail this very ancient red herring across the track." The only comment I have to make on what is said in the passages quoted is "that praise from a friend, or censure from a foe, is lost on heroes who our merits know."

In the editorial note at the foot of Dr. Thompson's letter you very correctly state that my claim rests upon much stronger grounds than mere self-assertion—not only is the specification describing my machine, to be seen at the Patent Office, but the machine exists, and if set into motion will develop current.

I may mention that my original dynamo was exhibited at the Inventions Exhibition of 1885, and for having designed the first self-exciting dynamo I was awarded the gold medal of the Inventions Exhibition, the committee consisting of Professor W. Grylls Adams, the Chairman, Professor Hughes, Mr. Conrad Cooke, and the President of the Electrical Engineers of 1885, Mr. Spagnoletti.

The only occasion when I have ever come into personal contact with Dr. Silvanus Thompson was at the 1885 Exhibition. Mr. Preece introduced me to him, and I invited both to inspect the working of my 1866 dynamo, which was declined by Dr. Thompson on the ground that he had "already seen it."

Dr. Silvanus Thompson has termed my dynamo claim "a very ancient red herring."

It was my fate to come more or less into scientific collision with the late Sir William Siemens. Dr. Siemens was a great power in the land. He has put the world under a great obligation, and much will, consequently, be forgiven him; but like many of those successful men whose name is writ large in the history of progress, he possessed strong shadows; he could not be fair to a contemporary.

In 1867, Mr. Ladd produced a dynamo machine, and Siemens claimed royalties from Ladd, which were resisted; Siemens's right to receive royalties was submitted to arbitration, and Sir Charles Wheatstone called the attention of the arbitrators to the specification describing my 1866 dynamo. In face of this document Siemens abandoned his claim; this fact alone speaks for itself.

Now, notwithstanding the fact that Siemens could not plead ignorance of my 1866 dynamo, he nevertheless ignored my claim in his public references to the discovery of the dynamo principle at scientific societies.

In 1877 I became involved in a journalistic discussion with Dr. Siemens, and it resulted in my claim being admitted in a paper read at the Institution of Civil Engineers in the interests of the Messrs. Siemens, but Professor Tyndall, at the meeting attacked my claims; the grounds on which this *large* souled physicist contended that I had no claims whatever, were that I had neither read a paper before the Royal Society, nor had I described my machine in a journal *which scientists recognised.*

One of the last public acts of the late Sir William Siemens was to give one of a course of lectures delivered at the Institution of Civil Engineers in 1883, the lecturers including among others Sir William Thomson. Siemens's lecture was delivered on the 15th of March, 1883, and in the course of his remarks he referred twice to the paper he read at the Royal Society in 1867 describing Dr. Werner Siemens's discovery of the dynamo principle and he antedated his paper by two years, stating that it was read in 1865 instead of as was the case in 1867. Now Dr. Siemens not only gave verbally an incorrect date but he allowed it to go forth to the world uncorrected as will be seen by a reference to the published lectures issued on the authority of the Institution of Civil Engineers. Now there were several present at Dr. Siemens lecture who were both his personal friends and who well knew the date when his Royal Society paper was read. If my memory serves me right Sir William Thomson himself was present, but I may be in error, anyhow I think it probable that if I were to say that I am of opinion that the error of date was not an accidental one, that Sir William Thomson might be induced to write that it was simply impossible for his friend the late Sir William Siemens to have allowed knowingly such an error to go forth. It is of course open to argument that the error made was accidental.

It is my intention when the appeal now before the House of Lords is disposed of (which the Brush Company do not seem to be in a hurry about) to write a history of the dynamo.

S. Alfred Varley.

March 17th, 1891.

[It is desirable, now that letters from Prof. Thompson and Mr. Varley appear in the same issue, that this correspondence should cease. It is becoming monotonous even to those who sympathise with the latter, and we can well afford to wait for the publication of his projected work on the dynamo, when doubtless the professorial element may again have to answer for itself.—EDS. ELEC. REV.]

C. H. W. Biggs—His Book.

Your reviewer in his original review attempted to be witty—in his reply he attempts to be wise. In both attempts he fails. I shall not travel with him in Dante's footsteps, but will confine my remarks and pin him down to his reiterated statement as regards a "most important first principle"—that being his *pièce de résistance*—his own chosen ground. You must not be surprised if I drive home to the hilt the

lack of intelligence, the lack of knowledge, and the impotence of any attempt to understand, as shown by the review and the reply. I am fond of quotations, and would humbly commend a study of these sentences: "In all our undertakings let us first examine our own strength, the enterprise next, and, thirdly, the persons with whom we have to do." One more, applying directly to legitimate criticism: "The first is concerning the true correction and edition of authors: wherein, nevertheless, rash diligence hath done great prejudice. For these critics have often presumed that that which they understand not is false set down." Whether your reviewer—supported by you editorially—has used "rash diligence" and understood not, I will now see.

Has your reviewer ever heard of "the diameter of commutation?" It may be that he has, and perhaps he may also, by attentively reading the authors he so kindly refers me to, find that the position of dynamo brushes, or brushes for coils such as I refer to in my book, are placed (when no armature reactions are considered) "so that the commutation shall take place exactly as the loop passes through the vertical position" (Prof. S. P. Thompson, third edition, p. 37). Now, why are the brushes so placed, if it is not to get the greatest difference of pressure (for shortness hereafter simply pressure), and thus the greatest current? Of course the brushes are placed at the extremities of the diameter of commutation, because we thus get the greatest pressure.

In this result, I am absolutely at one both with Prof. S. P. Thompson and every practical man who ever constructed or ran a dynamo, even though I suggest a different way of getting to that result, and it is your reviewer, not I, who gives a "sample of his bosh." He distorts my language, puts it into his own words, and conclusively shows he has obtained no glimmer of the sense of the words he has read. His mind has been so preoccupied with the idea of bringing me on my knees, that there is no room for its further activity. I say the reviewer distorts my language; he does more, he attributes language to me that I do not use, and which I repudiate. I explain pressure by the looping of lines around a conductor, not by the cutting of lines by a conductor. The former method allows me, I think, to explain more simply why brushes are put where they always are, is more consistent with what obtains elsewhere, and is capable of proof as to its correctness. I will now quote Mr. G. Kapp, who explains the obtaining of pressure by the cutting of lines of force, but see what his argument comes to, p. 56. "The maximum of the E.M.F., irrespective of sign is evidently $\text{E} = \text{F}\, d \frac{n}{60} 2\pi r$. Now, $2\,r\,d$ is the total space swept by the wire, and $\text{F}\ 2\,r\,d$ is the total number of lines passing through that space." Let us see where Mr. Kapp and myself differ. Mr. Kapp argues that the voltage is due to the number of lines cut per second. I argue that the voltage is due to the number of lines looped per second. I have not said nor indicated in any way whatsoever that the *rate* of looping lines is not greater when the coil is moving through a uniform field at right angles than when parallel to the field. Mr. Kapp, to get his total E.M.F., has to calculate the total number of lines through the area of his loop when vertical. At the end of his summation his wire is vertical, at the end of my summation my wire is vertical. Both Prof. S. P. Thompson and Mr. Kapp, as I read them, agree with me in this particular, though my reasoning to obtain this result is not the same as theirs. It is your reviewer's mental aberration that has led him into a mental quagmire, unless, indeed, you prefer the other alternative—utter ignorance not only of what I say, but of the authorities mentioned and of universal practice—a retort which, under the conditions of discussion, I am perfectly justified in making. Your reviewer is in this position: He has to show that the universal practice of placing the brushes at the extremities of the "diameter of commutation" is wrong. He has to show that the maximum pressure is not due to the summation of lines cut or looped, but to some other cause.

This is what I say, pp. 78-80: "Suppose the circuit, R T B, at the start horizontal—that is, with minimum or no loops around it—the bottom member, B, being at the right hand nearest to the pole, N, of the magnet. Directly the handle begins to move loops are formed around B; *the number of loops increase till the circuit is vertical.* During this time the current in the circuit *increases* from its minimum to its maximum." (The italics are mine.) It may be a consolation to your reviewer if I state that I can show experiments to prove this statement as I intend it to be read. At the same time I can show the experiments and get the results he has in his mind. This may be queer to him, but so it is.

There is nothing here to determine the *rate* of increase at any single portion of the movement, but your reviewer might be tempted to deny that pressure is due to number of loops. If he admits that, he might say "but increase depends also upon velocity of coil." This would be fair criticism.

I never "assert that when the conducting wires of a closed armature coil are *moving* through or *cutting* a uniform magnet field *at right angles* there is *no* E.M.F.," &c. (The italics are yours.) My reasoning is just the contrary. The coil I refer to is stationary, and neither cutting nor looping when I say there is no pressure.

I may inform your readers that the difference of electrical pressure—that is E.M.F. at the brushes of a dynamo—is least when the brushes take off from those coils wherein the rate of addition of lines or loops is greatest, and is greatest when they take off from the coils wherein the rate of adding lines or loops is least, the total pressure being the summation of a descending series of numbers representing the lines looped, and the total current is proportional to the pressure.

To make this point still clearer, let a turn of wire be in the horizontal position, when the field magnets are not excited. Now excite the field magnets and note the current. Stop excitation, shift the coil through, say, an arc of 30 deg. Excite the field magnets again, and note the current. The current will now be larger because the number of loops around the conductor is larger. Shift the coil through another 30 deg., and excite the field magnets again. The current is still greater. Lastly, place the coil in the vertical position and again excite the field magnets (of course, each excitation is to be similar); the current, with coil vertical, is larger than in either of the previous cases. Your contention is only correct when discontinuous action is considered, and when the lines cut, or loops added, are cut or added in such a manner that their summation does not give the total pressure, as will be the case when exploring the field to find the point of greatest pressure, but which is not the case in a dynamo, nor in a single coil moving with sufficient velocity. Of course, you have still the loophole that you did not understand me to mean what I say I do mean. I have only to say, in reply to this, that just previously to your quotation I have referred to discontinuous looping, giving momentary currents; and just after I define a volt pressure as due to so many loops *per second*. I have taken this attack on my knowledge of "an important first principle" as a sample of your reviewer's acumen, and having shown his misconception, must, like him, leave readers to form their own conclusions, for both his review and reply are so

"Free from dull order, decency, and rule,"

that it would take more space than you can well spare to even gently inculcate the ideas that not only with regard to the "first principle," but in other cases he "has blundered."

I contend that I have proved—(1) your reviewer to have put his own words and his own interpretation in the place of mine; (2) that in this particular case of E.M.F., where coils are moving through a uniform field at right angles, except in using the word "loops" instead of "lines," I do not differ from the authorities cited; (3) that he neither understands what I say, nor the authorities he calls to his assistance.

I must retract my promise to publish and criticise all the reviewers say about my book, for this reason: that much of what has been written bears too evident an undercurrent of personal bias, which prevents well-considered, impartial criticism. You will forgive me for saying that, while I wish every success to the *Electrical Review*, even violent attacks will not continue to draw replies, though I might be in a fighting humour, and the attacks as easily put aside as the attempt to prove me wanting in knowledge of first principles.

C. H. W. Biggs.

[We do not think that any good can come of continuing this discussion. The reviewer of the book, a gentleman particularly well-known in electrical circles, has no animus against Mr. Biggs, therefore his last paragraph could well have been spared.—EDS. ELEC. REV.]